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McGibbon, D. M.
Mears, Miss R.
Miller, Miss M. N.
Munro, D.
Murray, J.
Ritchie, G. S.
Webster, Miss E. M.
White, T. C.

V. Ireland

Adams, C. P.
Bonnar, Miss E. M.
Dallas, H. A.
Dockrell, R. B.
Fitzgerald, G. M.
Friel, Prof. S.
Keith, J. E.
McKeag, H. T. A.
Scott, J. H.

VI. Isle of Wight

Audsley, C. W.

VII. Colonial and Foreign

Africa
Braude, B.
De Villiers, J. F.
Edmondson, R.
Fainsinger, B. E.
Maister, H. C. L.
Williamson, M. M.

Australia
Adamson, K. T.
Halliday, R. W.
Heath, J. R.
Norton, R. Y.
Reading, J. F.
Seward, J. T.
Spring, D.
Taylor, A. Thornton
Webb, V. P.

Belgium
de Coster, L.
Patcas, H.

Burma
Brears, O. B.

Canada
Franklin, G.
Mulligan, W. O.
Oliver, H. T.

Egypt
Bakry, A. L. H.

France
Beauregardt, A.
Demoge, P. H.
Gugny, G.
Omeyer, R.

India
Ghosh, A. S.

Iraq
Mirza, Y. H.

Malaya
Cheah, C. K.

Malta
Demajo, A.

New Zealand
Bliss, H. D.
Cook, C. C.
Gilbert, G. H.
King, Mrs. W.
Lang, E. T.
Suckling, J. G.

Norway
Selmer-Olsen, Prof. R.

Sweden
Aslund, Mrs. K.
Granerus, R.
Granse, K. A.
Ljungdahl, L.
Lundstrom, Prof. A.
Palsson, K. F.
Tegner, G.
Volmer Lind, H. C.
Werner, S. H.

Switzerland
Hotz, Prof. R.

U.S.A.
Ceremello, P. J.
Goldstein, M. C.
Gosman, S. D.
Gottlieb, A. W.
Hellen, Mrs. M.
Parfitt, Prof. G. J.
Sillman, J. H.

THE NEW LOOK IN ORTHODONTICS

By J. H. HOVELL

THERE can be no doubt that present-day "orthodontics" is very diffcrent from orthodontics before the war. In fact the very meaning of the word describing our specialty has changed, and when we use it we mean something quite different from the narrow specialty which it used to define.

Let us cast our minds back twenty years for a few moments, and try to recapture the way we thought in those days. Our approach was purely mechanistic: most young orthodontists, and I was myself certainly one of those, were attracted to the specialty because we enjoyed fiddling with wires, and the manual ingenuity and dexterity necessary for the design and construction of intricate appliances. It was those fixed appliances fitted by Miss Smyth, then a newly-appointcd demonstrator at the Royal, which drew me into this sphere of dentistry.

It was Edward Angle who was mainly responsible for this purely mechanistic approach. His brilliant mechanical ability plus his dogmatic teaching of the necessity for producing by treatment ideal arches and ideal occlusion led to a complete stultification of orthodontic thought in America, and had repercussions on this side of the Atlantic which even yet have not completely died down. His opponents were regarded as heretics, and in this country it was generally considered that we were far inferior to the Americans, who were the only orthodontists capable of providing first-class treatment.

How far the influence of Angle, and the attitude of mind thus established, retarded true advance in orthodontics it is difficult to say. In those days scientific methods of research and criteria of the results obtained as we use them to-day were developing only in the hands of the few back-room boys, and were still not appreciated by the majority of clinical workers.

Reference to the literature of that period strikingly demonstrates this difference in outlook. For example, in a short section in Bennett's *The Science and Practice of Dental Surgery* (1931) entitled "Diseases associated with Teething", there are no less than sixteen statements commencing "X considers" or "In Y's opinion"; the whole of the remainder of the text is in exactly the same strain without reference to a single scientifically conducted experiment, or series of clinical observations. It was only necessary for a so-called authority to produce a theory, based only upon a few selected cases, or even on only one case, with no controls and no attempts to exclude other possible factors, for it to get into a textbook.

Many of these statements pass unchanged into fresh editions and fresh books, and have thus come to rank in the minds of the profession as established facts. An outstanding example of this is the statement that mouth-breathing is productive of underdevelopmcnt of the maxilla and various malocclusions, although, starting with Brash, numerous workers have shown that not only is there no evidence to this effect, but in fact such evidence that we have is entirely to the contrary.

Another example of this uncritical acceptance as facts of statements which were so unsupported that they barely merited being termed theories, is seen in Bennett's classification of malocclusion. A brilliant man, Bennett evolved this classification based upon aetiology, and widely acclaimed at the time by the profession, yet two of the three classes were stated to be due to "developmental defects of bone" without any attempt being made to produce evidence that this was in fact the case.

Now a man must either be very brave or very foolish to make a statement at a meeting of a learned society which is not well supported by facts, and this statement itself cannot be accepted as true until it has been confirmed definitely by other workers.

Presidential Address given at the meeting held on January 9, 1956.

This change in outlook is not, of course, confined to orthodontics; in fact the reverse is the case. The art of scientific investigation, as it is so aptly termed by Beveridge in his excellent book, has developed most rapidly in the basic sciences and non-clinical branches of medicine.

This is due partly to the difficulty of applying strictly scientific methods to clinical research on humans, and partly to the lack of understanding by the clinical worker of the basic scientific requirements which must be conformed to, if his research is to be valid.

Very careful planning of research is necessary in co-operation with a statistician. Many pieces of work have been rendered quite valueless because of failure to do this. Beveridge's book *The Art of Scientific Investigation* and Bradford Hill's *Principles of Medical Statistics* are two works which must be read, learned, and inwardly digested by any aspiring young research worker as an essential first step towards his goal.

Of all the branches of science, orthodontics was the slowest to conform to these universally accepted standards—for many years, indeed until after the war, it was hardly more a science than is the medicine of the African witch-doctor.

However, important and essential as the scientific and statistical method is in the establishment of facts, this is work that can be done by any intelligent worker with the requisite basic knowledge and training. A piece of research cannot just be started out of the blue; it must have a definite objective. As Darwin said: "All observation must be for or against a view if it is to be of service." There is a small class of research workers who have the uncommon quality of being able to grasp the significance of the unusual, an idea which was stressed by Walshe when he said that "It takes the exceptional mind to pass beyond the first exercises of the discriminating tendency to pick up a hitherto unrecorded phenomenon and to grasp its significance. Indeed, many a competent clinician may live out his professional existence, never having made a truly original observation."

Spence makes exactly the same point in dividing clinical observation into three main categories:—

1. Observation of the established signs of disease which act as a guide in diagnosis and prognosis.

2. Recognition of new phenomena or new correlations between previously observed phenomena. This is rare and is the attribute of the truly brilliant research worker. In medicine one can cite the discovery by Gregg of the association of maternal rubella between the eighth and tenth weeks of pregnancy with certain congenital deformities.

We are fortunate in this Society to have as members two such men—I refer, of course, to Ballard and Rix, both of whom, working independently, recognized the importance of soft-tissue behaviour and morphology relative to the shape and relationship of the dental arches.

3. Planned clinical observation—this is work for the trained research worker and must follow the observations of the preceding category.

Huxley stresses the importance of the original and perhaps heterodox observation, when he says: "Those who refuse to go beyond fact rarely get as far as fact. Almost every great step in the history of science has been made by the invention of hypotheses which often had very little foundation to start with."

Ballard and Rix were fortunate that they produced their ideas at a time when the orthodontic profession in this country was ripe to receive them, and when the development of cephalometry as a purely mechanical research tool has enabled many of their views to be substantiated and expanded. Every new idea now, as always, has to be fought for against what Bernal calls the "regressive forces of pedantry and obscurantism". It must be remembered that in the third century B.C. Aristarchus taught that the earth rotates around the sun and upon its own axis, for which view he was charged with impiety! Mendel's famous experiments lay forgotten for many years, until they were rediscovered when the scientific world was ripe for them.

One last word about the research worker, and again I quotc Bernal: "No scientist can be, nor can he seriously want to be, guaranteed against reversals of judgement in the long run. All he can hope for is to establish enough valid and significant connexions betwecn facts, even if they are later overthrown, to serve as a basis for finding new facts and new connexions. The greatcst difficulty in discovery is not to make the necessary observations but to break away from traditional ideas in interpreting them."

With regard to the work of Ballard and Rix, we are now at the point when the second category of research worker must get going, and establish by large-scale scientific investigation the validity or otherwise of their assumptions. So far there is to support them a great mass of clinical evidence, both in children and adults, dentulous and edentulous, and also the fact that treatment based upon their views gives the results that would be expected. In addition, many causes of relapse, hitherto unexplained, and varying responses to treatment, fall neatly into place when viewed against the background of soft-tissue morphology and behaviour.

All this, however, is not sufficient; we still must consolidate this position by the accepted scientific method. Only this year, at the E.O.S. Congress, I was asked by Lundstrom why we had not done this in view of the fact that we felt so certain of the fundamental importance of this aetiological factor. What a field there is at the moment for the young orthodontist! In almost every case I see, every clinical demonstration I give at hospital, some point arises, the elucidation of which could provide a piece of work, often not on too large a scale, which would be excellent training for any young man prepared and able to devote the time and energy to its prosecution. This is indeed a change. When I was a young man wishing to take up research, I tried to obtain advice and help from my seniors, without avail. It was not that they were unwilling to help, but that the purely empirical nature of orthodontics, and the unscientific training and outlook in dentistry at that time, had resulted in complete sterility of thought—the mechanical field had been exhausted—Friel had left nothing for anyone else; the scientific field was still to be opened up.

This new outlook, with an ever-increasing scarch for basic aetiological factors, has immensely widened the scope of orthodontics, so that not only is it now the foundation stone upon which most dental knowledge is and education should be built, but it impinges upon many non-medical branches of science. I would like to mention a few of the ramifications of orthodontics, both inside and outside dental surgery. Let us take periodontology to start with. Both Ballard and myself have read papers pointing out a possible relationship between periodontal disease, malocclusion, and abnormal orofacial behaviour patterns. Many periodontologists deny this relationship, others consider it important, but from a lack of fundamental orthodontic knowledge fail to conduct essential research along scientific lines. I think there is no doubt that in the future a knowledge of the basic principles now being investigated and established by orthodontists will be equally necessary for a periodontologist. Periodontology has not yet fully emerged from the empirical unscientific stage. Long words such as paradontosis and periodontoclasia are invented to describe clinical conditions and complete classifications, but knowledge of aetiology is sadly lacking, and will continue to be while the minds of periodontologists are concerned mainly with toothbrushes and mechanical procedures.

Prosthetics equally demands a knowledge of orofacial behaviour. Many years ago Fish produced his well-known technique for stabilizing the lower denture, based entirely upon muscle balance. Had he been an orthodontist, he might have gone further and been the first dental surgeon to describe variations in the orofacial behaviour patterns. These patterns persist unchanged in the edentulous adult and a knowledge of the displacing forces produced by the various types is essential for the full denture prosthetist.

In major oral surgery undertaken for correction of variations of the facial skeletal pattern, ignorance of the basic principles of

muscle balance and soft-tissue morphology may lead to incorrect diagnoses and ill-conceived surgical procedures.

Indeed, apart from the aetiology of caries, a knowledge of orthodontics, or perhaps I should say functional dental anatomy and physiology, is a first essential. Even single restorations improperly designed can, as has been shown by Beyron, throw the whole masticatory apparatus out of gear and ruin the health of the supporting structures of the teeth.

In a communication given at our Country Meeting in Sheffield last year, Ballard opened up a new field by showing the possible significance of behaviour patterns in animals with regard to orofacial behaviour, and drawing analogies between the two. He stressed the endogenous nature of the development of maturation patterns during ontogenesis and drew phylogenetic parallels. Psychologists, zoologists, and anthropologists have already found a subject of common interest in the study of displacement activities in animals and imprinter mechanisms in the maturation of behaviour. There seems to be little doubt that with regard to the results of animal experiments there is a similarity so close to the development of nervous disorders in humans, that similar neuropsychological mechanisms are certainly at work.

Let us look at a few examples taken from Russell's lecture in the *Scientific Basis of Medicine* Series. Psychological or nervous breakdown can be produced in animals by placing them experimentally in circumstances leading to conflict. On the ringing of a bell, dogs were shown either an ellipse or a circle. Subsequent to seeing the circle they were always fed, never after the ellipse. This produced a conditioned reflex of salivation on seeing a circle, and inhibition of salivation with the ellipse. When this reflex was fully established, the circle was made slightly elliptical and the ellipse more circular. At first the animals could differentiate between the two and the normal conditioned response occurred. As the shapes of circle and ellipse became more similar, a point was reached in which the dogs could not differentiate between the two, resulting in frustration and complete nervous breakdown. Exactly similar situations are shown by psychiatrists to result in nervous breakdowns in humans.

Rats subjected to frustration produce a behaviour pattern of strikingly rigid fixity. When confined in a cage with two doors, one unlocked leading to food and one locked, they soon learn at a given signal to jump at the unlocked door. If the position of the locked door and unlocked door is now switched at random, the result is usually a fixation upon one given door which is always jumped at. It is now found that this behaviour pattern is so firmly fixed, that it is difficult and may even be impossible to re-educate the rat to jump at a given unlocked door—before the development of this fixation a simple matter. An analogy between this behaviour in animals and thumb-sucking and possibly atypical swallowing actions can be seen.

Quoting from Russell, behaviour disorders are thus produced under conditions in which some occurrence, possibly itself environmental, interferes with the adjustment of an organism to environmental or organic changes. There are two main types of occurrence. In one the obstruction is such that the organism lacks the ability to overcome it—frustration resulting in fixation of behaviour; in the other inability to differentiate between stimuli giving rise to incompatible responses leads to conflict. For example, artificially nourished puppies and calves restrained from nipple-sucking may develop abnormal behaviour patterns of licking paws, other dogs, and inanimate objects to a degree which is sometimes harmful.

The genetic background which modifies the effects of conflict and frustration is shown by the experiment in which selective breeding of rats produced two strains, the one highly stress-resistant and the other very susceptible to stress.

It is probable that an orthodontist could do much valuable work in collaboration with a biologist and a neuropsychiatrist along these lines. The criticism has been made that man is not an animal—unfortunately he is—hence most of our trouble. I am sure that Ballard's phylogenetic approach to disturbances of behaviour is the correct one, and again quote

Russell, who says: "Many investigators take a comparative phylctic approach to this work. This is necessary in many branches of biological and medical research owing to limitations on the use of man as a subject. Such research involves extensive observation of homologous behaviour patterns in a variety of forms, which may lead to the discovery of general principles. Care is needed in assessing results and applying them to man, but much research of this type has in the past yielded outstandingly valuable results."

Clinical observation leaves little doubt that sucking habits are often found in children of a definite neuropsychological type, and are also commonly associated with variations from the normal swallowing action. Ballard's tentative observations, which at first sight appeared somewhat remote from orthodontics, are found on deeper study to have opened up a field for research far beyond the original frontiers of our specialty, which may well lead to the discovery of facts of great importance and aetiological significance.

With regard to imprinter mechanisms and displacement activities, we are on ground even less fully explored. There appears to be little evidence at present that these mechanisms, whose effect is so ably described by Lorenz, Tinbergen, and others, in guiding and organizing development of behaviour in animals, act in the same way in humans. Study of behaviour in humans is much more difficult owing to the influence of intelligence in masking or perhaps even controlling innate behaviour patterns. I quote, however, from a letter received from S. A. Barnett, of the Zoology Department, Glasgow, to whom I wrote on this subject. He says: "It seems very likely that there is a fundamental connexion, in terms of nervous function, between displacement activities and the behaviour patterns of children which you mention. The main problem as I see it at the moment is to devise methods of study which could establish such homologies empirically."

What an enthralling field for research is opened up by this particular "new look".

I will turn now from the sublime, if not to the ridiculous, at least to the more mundane aspect of orthodontics—that is orthodontics in the Health Service. Here again a revolutionary change has occurred. In the past orthodontics was a branch of dentistry which to the general practitioner was to be avoided at all costs. The growing tooth-consciousness of the general public, added to pecuniary encouragement of the Health Service itself, has changed all this. Most general practitioners, some willingly, some unwillingly, undertake a varying amount of orthodontic work in their practices. The hospitals and few school orthodontic clinics just cannot cope with the demand, so that waiting lists reach such a length as to become a mockery.

When one considers the changes in orthodontic thought that have evolved during the last ten or even five years, it is not surprising that quite apart from their lack of experience in techniques, the majority of men who qualified longer ago than this have no knowledge of the basic principles underlying correct diagnosis: and without correct diagnosis correct treatment planning is impossible, or at the best is empirical and a matter of chance. Please do not think I am running down these general practitioners, who like the general medical practitioners, are the backbone of their profession: it is no fault of theirs that a changing social system has left them high and dry. Nevertheless something has got to be done about it. I can well imagine what a headache this set-up gives the Dental Estimates Board. They are acting as guardians of the country's money—of our money—and are in reality controlled by the Treasury rather than the Ministry of Health.

Having worked on Replanning and Establishment Committees and a hospital Board of Governors, I know well that when the Treasury through the Ministry allots a certain amount of money for a certain purpose, that sum just cannot be exceeded. The Dental Estimates Board is in the position of having to allot the limited sum of money at its disposal to the best possible advantage of the British people. I have no inside knowledge of the workings of the D.E.B., but by what Ballard calls "inductive reasoning" it is quite obvious that a high proportion of the treatment plans they

receive must be doomed to failure or ultimate relapse, in fact at hospital one is often called upon to give second opinions upon cases of this type. One case seen recently was a severe Class II, Division 1 malocclusion with crowding of the teeth upon a postnormal dental base relationship, in a girl of 16 years of age. The treatment recommended was upper and lower expansion followed by an Andresen appliance. The Dental Estimates Board, in a polite and tactful letter, suggested that in their experience such treatment at this age in this type of case was unlikely to prove successful, and would the dental surgeon in question consider extraction in treatment. The dental surgeon in question sent the case to me with an indignant letter, asking me to uphold his professional judgement, which, however, I was quite unable to do. I think it is significant that in the increasing number of cases being sent to me, as a result of a request from the D.E.B. for a second opinion, in not one have I been able to agree with the original treatment plan, in spite of my desire to support my professional colleagues whenever possible.

It is my impression that orthodontic cases are only turned down, held up, or queried in cases in which the treatment plan is not merely questionable, but obviously incorrect. It must be remembered that the Board has an orthodontic consultant to give advice in these cases. The Board also knows by now, as a result of experience, which practitioners are actually producing good stable results in treatment, and which are in fact only wasting the country's money and the patient's time. The only weapon they have against the latter group, and it is in the country's and the patient's interest that it should be used, is the use of red tape with delays, quibbling, and all the petty annoyances and resentment which are thus engendered: they are not permitted to query the dental surgeon's professional judgement, and the latter himself is almost always acting in good faith and becomes rightly aggrieved at the way the proceedings are carried out.

This is a most unsatisfactory state of affairs, and it is evident that the Ministry is well aware of this by recent action that has been taken. It was originally envisaged that specialist treatment, such as orthodontics, should be carried out in hospitals and health centres by specially trained staff under consultant guidance. The trainee specialist scheme was introduced so that future consultants could be trained along the right lines to be able to take charge of these teams. We have now reached the time at which this scheme is maturing—an adequate number of young men have progressed up the trainee ladder and are now ripe for such appointments. Unfortunately, the heavy hand of the Treasury has again intervened. There is not enough money available for the building and staffing of health centres to absorb these men and carry out the treatment.

The Ministry has shown its awareness of the urgency of this problem by recent memoranda to Hospital and Regional Boards, stressing the advisability, in fact the urgency, of creating consultant appointments in Orthodontics. Even in this respect their hands are tied by the Treasury—that is to say, by the financial resources of the country; we are already taxed quite highly enough; and these Hospital and Regional Boards in most cases have to find the money for these new appointments from their own allotment of Treasury funds, by means of economies elsewhere. Progress is, therefore, necessarily slow.

Also, owing to the altered circumstances, the duties of such a consultant are necessarily different from those originally envisaged. He is not to have a staff of specially trained dental surgeons and trainee specialists working under him. He is virtually on his own. How, then, can he best serve the community and the profession! I think it is by making good to the best of his ability the deficiencies in orthodontic knowledge of the general practitioners in his area, so that they themselves are able to carry out under his supervision and guidance, basic orthodontic treatment for all but the most difficult cases. This means that he himself will have little time for actual treatment, although in my opinion he must as it were keep his hand in by doing a certain amount of treatment, say the equivalent of three sessions per week, for the rest of his

consultant career. He will have to organize study circles and postgraduate courses in his area. This may involve travelling and a considerable amount of work outside normal working hours. He must keep actively in touch with every dental surgeon in his area, whom he can persuade to co-operate with him, giving advice wherever necessary, and initially probably carrying out the treatment planning for almost all cases.

It is going to be hard and uphill work, but interesting and rewarding. In my opinion, such posts, when created, should go to the young energetic men who have been specially trained for this work under the trainee specialist scheme; there are many of them waiting for jobs and well capable of filling them. Under these circumstances I believe it to be contrary to public and professional interest to appoint to such a post any man of over 40 years of age, however eminent.

So far I have spoken of the effects of past educational methods, adapted to the needs and knowledge of the time upon present-day requirements. It becomes obvious that with the present set-up—one which in view of purely financial limitations is likely to last indefinitely—the education of the student and the requirements of the qualifying bodies must be adapted to the needs of the profession and our patients. In this respect I have just completed, in a career full of changes of mind, what I consider to be my most complete *volte-face.* It has always been my view that orthodontics should be a postgraduate subject and that for the undergraduate instruction should be confined to the essentials of aetiology diagnosis, and treatment planning—treatment as such should be omitted almost certainly.

The reasons for my change of opinion are twofold. First is my conviction that the basic principles of orthodontics are the basic principles of dental surgery as a whole, and therefore must be taught and understood by the undergraduate if he is to develop into a first-class dental surgeon. Second is the very definite need now for the general practitioner to be able himself to carry out orthodontic treatment for his patients.

When I was a B.D.S. examiner with Rix, we cut out the practical part of the examination. I have a feeling now that we were wrong in so doing and that there is a good case for re-introducing this. With regard to the L.D.S. examination, because there is no special orthodontic section, and no orthodontists upon the board of examiners, candidates know full well that no knowledge of orthodontics whatsoever is necessary in order to pass their final examination. This is a very bad thing, because these students are thus encouraged to ignore in their studies a vital and essential part of dental surgery, without knowledge and comprehension of which they are only too likely to remain at the level of pure technicians—a criticism which has only too often been levelled at dental surgery by our medical colleagues.

I think that the College should—in fact must—take notice of this state of affairs, and so change the requirements of the final L.D.S. examination to bring it into line with the B.D.S. The new Dental Bill, with its significant section upon the training of ancillaries, foreshadows great changes in the dental profession of which we must be aware, and of which we must make use, if we are to maintain and in fact improve our status. By the possibility of relieving us in the future of much of our purely routine mechanical work, the Bill offers the profession a unique opportunity of rising above the level of pure technical achievement, to becoming a prescribing profession, on the level if not of medicine at least of surgery.

Here is our big opportunity; we must grasp it with both hands, and it lies I think with orthodontics, the most scientific and progressive branch of dental surgery at the moment, to make possibly the greatest contribution towards the future of dental surgery.

It is to be hoped that the regressive forces of pedantry and obscurantism within the body of dental surgery do not, in a vain endeavour to stem the tide of advance, prevent us from using to the full the opportunity presented.

I have tried to show that the "new look" in orthodontics is not just a change in ideas of aetiology and in philosophies of treatment, but goes much deeper. It is a radical change in our professional outlook which must spread

to all branches of dentistry, raising it from a purely *ad hoc* technical skill to its proper place amongst the scientific and learned professions. The opportunity is now ours and we are capable of grasping it, and I feel and think that we shall do so.

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DISCUSSION

Mr. D. P. Walther said he would like to congratulate Mr. Hovell on his election as President of the Society and to thank him for the New Look which he had given the Society in this New Year. It was a magnificent New Look, full of great opportunity and hope and indicating a great future. Mr. Hovell had certainly put a great deal of time, hard work, and his usual boundless energy into his New Look and had drawn from his vast personal experience.

He liked the title of the address and had immensely enjoyed the address itself, which he had found very encouraging. It had brought home to him what a tremendous amount of research work had yet to be done and what a wide and fascinating field was open to orthodontists.

The President had traced very clearly the progress of orthodontic thought up to the present time. He wholeheartedly agreed with the President that orthodontists were now just on the brink of what was quoted in the address as Spence's Category 3. From Category 2 they had been presented with numerous theories which seemed quite logical in certain eases, but there was still a vast amount of work to be done.

He had been delighted to hear the President say: "We are now at the point when the second category of research worker must get going and establish by large-scale scientific investigation the *validity* or *otherwise* of their assumptions."

The President had also stressed, he thought very wisely, that this large-scale clinical research must be well planned and must be undertaken by suitable personnel who had been well trained in scientific research methods, including, of course, statistics. He hoped that in time, therefore, the science of orthodontics would be raised higher than the medicine of the African witch-doctor. Seriously, however, although there was still a great deal of research to be done, orthodontists must be very grateful for all that had been done in the past.

He had been pleased to hear the President say that orthodontics was now the foundation stone upon which most dental knowledge and education should be built. He felt with the President that many periodontologists, prosthetists, and others might well derive great benefit from attending some of the Society's meetings, as in fact it did orthodontists a world of good to attend theirs.

He had been extremely interested in the President's views on orthodontics under the National Health Service. He agreed with the President that the Dental Estimates Board had a very difficult task to perform. The President had given a very clear picture of what was going on. It was a good thing that the Ministry realized the importance of the orthodontic problem, and he hoped it would not be long before the requisite money was forthcoming. It was very important to have orthodontic consultant appointments if the trainee specialist ladder was to be maintained.

The President had concluded his address very courageously by describing his change of attitude towards undergraduate orthodontic instruction. What the President had said in that connexion was very true indeed, and he hoped that both the College and the University would take notice of what the President had said and would do something about it.

Orthodontic teaching was essential in the training of the specialists and consultants, and there should also be refresher courses to keep general practitioners up to date and to help others to carry out treatment under consultant advice. The teaehing of orthodontics should take a higher place in the undergraduate curriculum, and it could do this only by the whole course being lengthened or by the amount of time devoted to other subjects being reduced. He thought the time had now come for a thorough revision of the whole dental syllabus.

In conclusion, he would like to thank the President for his most enjoyable address and to wish him a very happy and successful year in office.

Mr. N. J. Ainsworth congratulated the President on his address and said it was a remarkable fact that it was the first orthodontic address every word of which he had understood and the sentiments in which he heartily endorsed.

The meeting then terminated.

AN ANALYSIS OF TREATED CASES

By **W. GROSSMANN**, M.D., L.D.S.R.C.S., and **B. E. GREENFIELD**, B.D.S., F.D.S.R.C.S.

PART I.—INTRODUCTION

(W. Grossmann)

IN a survey of cases treated in the Department or Orthodontics at University College Hospital we were again surprised to find the great difference in the response of many cases to similar treatment, the abnormalities having been caused as far as can be assessed by similar aetiological factors. Those findings are of course by no means new, but we had thought that modern knowledge of aetiology and of tissue response would allow us to develop a more definite prognosis for our cases. The uncertainty of treatment response, and above all its final stability, has no doubt been responsible for the various philosophies we have seen put forward during recent years. Many of them have since been rapidly abandoned. Let us consider the cephalometric profile X-ray. How many orthodontic schools thought they had found the diagnostic and prognostic aid which they had been looking for? The amount of scientific investigation and publication that followed showed clearly that we were still a long way from our aim. In cephalometric investigations we have found a very promising scientific aid for further research, but by no means have we been provided with all the answers we had hoped to obtain.

On a recent tour of the United States I was surprised to see how some of the schools rely once again predominantly on their clinical methods of investigation and are using cephalometrics for scientific investigations only. It is so simple to work out the right incisor relationship and its ideal angulation. With powerful appliances it is even possible to move the teeth into the desired position, but to keep them there was so often found impossible, in spite of its ideal geometrical alinement. The same schools were fully aware of modern thoughts on the influence of the facial musculature on the shape of the dental arches, and were even involved in practical muscle research, but very little attention is paid to its clinical application. I think we are all agreed to-day on the fact that muscular influences are partly responsible for the shape of the dental arches and are also an important factor in the stability of our orthodontic end-results. Far less certain is the assumption that muscular behaviour patterns are not significantly amenable to re-education or changes. Without trying to embark on long scientific explanations, I think the fact that a great number of cases, in which no doubt an abnormal muscular balance existed at the beginning of treatment, respond well and remain stable, shows clearly that an adaptation must have occurred. One of the difficulties at present is that the clinician has no reliable scientific aid to assess and record the muscular behaviour useful for comparison at a later date. Most of our observations are clinical assessments which are open to human error. Orthodontists very often talk of "muscular balance"—a far too loose term—and hardly acceptable to the muscle and neuro-physiologist; from the point of view of study of muscle function, the term "muscle balance" is meaningless. But if by this term reflex co-ordination of muscle contraction and relaxation is meant, then the principles that govern this have been well known—ever since they were established by Sherrington.

It has long been known that the reflex co-ordination of muscles varies with a great variety of influences. For example, merely stretching a muscle will lead to an alteration in the co-ordination of all muscles with which it is functionally related. For example, alteration of head position changes completely the pattern of co-ordination of the muscles of the masticatory organ besides all the muscles of the limbs.

Given at the meeting held on February 13, 1956.

If the statement is made that muscular balance is inherited, this can only mean that the reflex pattern of muscle co-ordination is inherited; and this could only be so if: (1) the neuromuscular structure of the reflex arc were inherited; and (2) all the factors affecting transmission of activity through the synapses in this structure were inherited. The first statement is entirely true, but the second is only partly true, in so far as environmental influences can alter transmission through the reflex arc. The whole basic physiology of athletic training rests on this fact, otherwise the athlete in training could never modify his muscle reflexes. Clinical observation and animal experiments, which are not fully applicable to human material, are to my mind not sufficiently strong evidence to produce far-reaching hypotheses, and while, as you have heard, electromyography is most useful, it still has a number of questions to answer.

A comparatively short time ago many of us believed that functional influences could play an important part in the development and growth of the masticatory organ. I myself mentioned this in a paper which I read before this Society; but I know to-day that this belief is untenable in the light of modern genetics. We, too, misinterpreted our clinical observations because we noted changes for which we could give no other explanation than that the altered function suppressed the inherited tendencies. At this time we believed that there was one inherited tendency only, but to-day we know that in every individual there are multiple hereditary tendencies which by no means remain latent throughout life and which may become prominent during times of rapid development and favourable environmental circumstances. This may give us the answer to our clinical observation that the response of some of our cases is often unpredictable and repudiates dogmatic statements that skeletal and muscular patterns are unchangeable. Saller, in a recent paper on heredity, states that besides the known geno- and phenotype there exists the so-called kryptotype. The presence of the kryptotype explains the environmental influences and possible changes in the constitution of an individual throughout life, even when the development in the beginning has been towards a different direction.

Let us look at the practical significance of these findings as far as they are of importance to the orthodontist.

Too much attention has been given by orthodontists to the observation of the undisturbed development in the individual and too far-reaching conclusions were then produced. Let me talk for a moment on the Mendelian laws of heredity. We generally speak of genotype and phenotype, whereby genotype means the whole of the gene-potential. The external appearance or visible habitus is spoken of as phenotype; it is the manifestation of the hereditary type as modified by external influences (peristasis). The hereditary anlage should not be thought of as something rigid; it is subject to various idio-kinetic influences that may modify the formation of the genotype. The kryptotype comprises a series of recessive tendencies and dispositions which still have their development in front of them. They can develop from the genotype to the phenotype, but only if the environmental influences are favourable for them.

To the orthodontic case there are two factors particularly important, which can influence the recessive tendency, the orthodontic appliance, and changed function. They can, however, influence the masticatory organ only if a suitable hereditary tendency is latent and strong enough to become dominant. This explains the different therapeutic results in similar cases treated by similar means. It also explains why lateral expansion is sometimes seen to follow even passive orthodontic treatment and progresses after treatment has been discontinued. We now can perhaps explain why, in certain cases which are of hereditary aetiology, such as Angle Class II, division 2, we are sometimes successful in our treatment; the dominant Class II, division 2 has been suppressed by a recessive tendency to a normal occlusion, which in turn has been through environmental influences helped to become dominant and suppress abnormal hereditary characteristics.

Sudden different development in uniovular twins leading to different occlusion is now easier to understand.

Newman, Freeman, and Holzinger compared the differences between identical twins reared together and the differences between those adopted at an early age and reared in diverse environments. The results indicated clearly that when heredity is constant as in identical twins, diverse environments produce differences—physical, and in intelligence and personality. Carmichael states that: the fact as it appears to the writer is that no distinction can be expediently made at any given moment in the behaviour of the individual after the fertilized egg has once begun to develop, between that which is native and that which is acquired. The so-called hereditary factors can only be acquired in response to an environment and likewise the so-called acquired factors can only be secured by a modification of already existing structure, which in the last analysis is hereditary structure.

Munn, in discussing unlearned behaviour pattern in the human being, states that: it is very doubtful whether there is anything here that one could call an "instinct", meaning a complex unlearned behaviour pattern. There are many relatively simple unlearned responses, but these are reflexes. The question of education and re-education is also affected by modern genetics. Schwarz once stated cynically that education of the human being is completed at birth. He really meant that education can only foster or suppress inherited tendencies, but add very little new. Education or re-education can therefore only succeed in cases which have inherited the necessary genetic tendencies and the structures appropriate for their display.

A clear example of environmental influence upon the masticatory organ is provided by thumb-sucking.

Thumb-sucking in cases which have inherited a tendency to a narrow upper jaw will show severe additional changes and even after the discontinuation of the habit no improvement will occur. On the other hand, thumb-sucking in a normal child with strong inherited tendencies to a well-shaped dental arch will not lead to malformation, but only to a temporary deviation which will return to normal as soon as the habit has been abandoned. The only exception is that a new habit has been added and the muscular balance has become disturbed, as for example when the lower lip remains between the upper and lower teeth and so acts more or less as a retention for the upper proclinated incisors.

In Angle Class II, division 2 cases, which we all know are mostly inherited malocclusions, thumb-sucking hardly ever changes the clinical picture. We have seen a number of cases, and Schwarz has published similar findings, where even after many years of persistent thumb-sucking the characteristics of Class II, division 2 remained uninfluenced. There may be a slight anterior open-bite in the area where the thumb lies, even a deepening of the palate, but the axial inclination of the upper incisors remains unaltered and only a forward movement is present, the teeth having been brought forward bodily.

The influence of mouth-breathing, adenoids, or tonsils on the masticatory organ, too, has been greatly overrated. In a child with inherited tendencies to characteristic deformities, no doubt additional damage can probably be the result. In a child with a strong inherited tendency to a normal bony and muscular pattern, the unfavourable environmental influence will be only of a very limited and passing nature. Strong inherited tendencies will remain uninfluenced by environmental changes. This means to us as orthodontists, that they are untreatable. Unfortunately we are in no position to-day to diagnose with certainty the strength of the inherited tendency. Only the treatment result will show whether we have been able by environmental changes to suppress unfavourable dominant characteristics and help recessive ones to come forward.

A few cases are shown out of our survey. Some of them will demonstrate how unpredictable treatment results can be. To obtain the maximum information we examined the cases as a team, Mr. Greenfield examining the muscular activity before, during, and after treatment. Mr. Grewcock kindly examined

cases in which we thought postural change in the mandible may have obscured the true occlusal relationship, and Mr. Eastwood and Mr. Timms have been responsible for the cephalometric investigation.*

From these cases and from the observations we have made I think it is only right to say that we have not yet by any means reached a stage where we are able to make exact prognostic statements of our cases.

* The number of cases shown at the meeting has been reduced for this publication. The number of illustrations for each case reported here has also been considerably reduced; original profile X-rays taken at the commencement and completion of treatment and the X-rays of the temporomandibular joints have been omitted.

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Part II.—ELECTROMYOGRAPHIC INVESTIGATION

(B. E. Greenfield)

Two years ago Professor Slome read a paper to this Society on the Physiology of the Muscles of Mastication and referred to electromyographic research, initiated by him, which was being undertaken at the Royal College of Surgeons. This work has proceeded to the stage where its clinical application is being developed in orthodontics, bite rehabilitation, and oral surgery; and I would suggest that the technique is applicable to the investigation and treatment of any case where the relation of the mandible to the maxilla is changed or where the disposition or occlusion of the teeth themselves is altered.

GENERAL PRINCIPLES

The details of the method have been fully described in a paper by Greenfield and Wyke (1956), and a preliminary report was presented by these authors at a meeting of the Anatomical Society at University College, London, in April, 1955. I therefore propose to give only a brief outline of the technique and then discuss in more detail certain electromyographic features of the cases described by Mr. Grossmann.

Electromyography is based on the fact that when a muscle contracts a change in electrical potential takes place in each of the muscle-fibres participating in the particular movement; this potential change constitutes the muscle spike potential. The aggregate of these potentials can be recorded using suitable electrodes placed either over or within the muscles to be studied. In the cases to be described here, surface electrodes were employed, attention being confined to the temporal and masseter muscles.

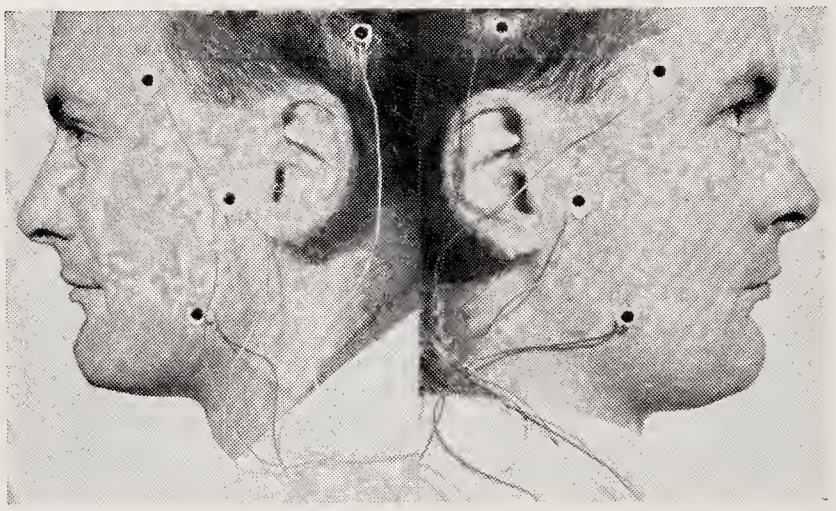


Fig. 1.—Standard electrode positions for routine clinical studies.

The position of electrodes for monopolar recordings, in routine clinical studies such as are to be described, is shown in *Fig.* 1. One electrode is situated over the anterior and another over the posterior fibres of the temporal muscle. A third electrode is situated over the posterior superior fibres and a fourth over the anterior inferior fibres of the masseter

muscle. These electrodes are symmetrically situated on the two sides of the head; a reference electrode is placed in the region of the sixth cervical vertebra; the subject is also earthed.

If electromyography is to be undertaken as a part of a clinical investigation it is essential that the same electrode positions are used at all subsequent examinations, and comparable positions utilized from subject to subject. The method for doing this is described in detail in the paper referred to.

Bilateral recording is of such importance that I will go so far as to say that any clinical work which relies only on unilateral investigations is useless in the study of the activity of the muscles involved in mandibular movements. These studies have revealed a basic pattern of reflex muscle co-ordination which is specific for each of the normal movements of the mandible.

Each movement in a normal individual involves a fundamental pattern of activity which is constant for that individual and remarkably similar in all persons with normal occlusion. But although this basic similarity exists, the pattern of muscular activity displays certain minor individual characteristics. For this reason, in these studies the pattern of muscle activity during individual biting is used as a standard with which to compare the co-ordinated activity of the muscles during other basic movements of the mandible.

In the conduct of the examination a series of standardized movements is undertaken by the subject. Each of these movements produces a characteristic electromyogram. After identifying these basic patterns they may then be used to analyse more complex movements.

Each electromyogram is investigated in terms of the amplitude of its peaks, the frequency of their occurrence, and their time of onset and disappearance.

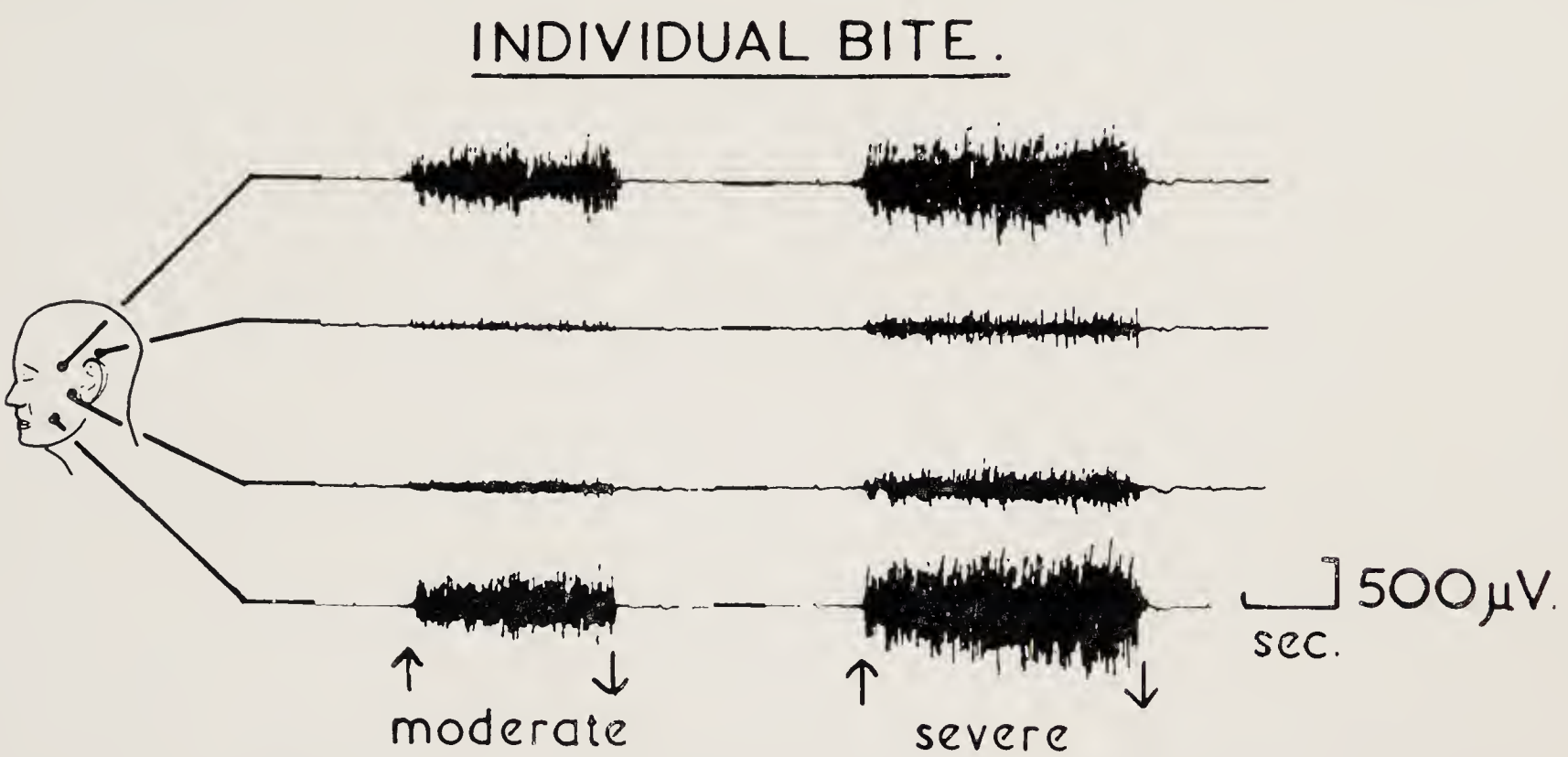


Fig. 2.—Activity during moderate and powerful individual biting.

NORMAL ELECTROMYOGRAPHIC PATTERNS

The following recordings will show what I consider to be the electromyographic patterns for the various basic movements in normal individuals.

Fig. 2 is a unilateral recording from the left in a normal adult. The first set of recordings show the activity of the muscles in the region of the electrodes during moderate biting and the second during more severe biting. With more severe biting there is increased activity (both in amplitude and frequency) of similar degree in the various parts of the muscles. The greatest activity appears in the anterior temporal and anterior masseter regions. The onset and cessation of activity is synchronous in the various parts.

The upper part of *Fig.* 3 is a bilateral recording from the anterior part of the temporal and masseter muscles of another normal subject. The first record shows the individual bite. The second shows the increased activity of the left anterior temporal fibres when biting on the left; and the decreased activity of the right anterior temporal fibres. At the same time the right anterior masseter fibres show greater activity than those on the left. The third record shows reversal of this pattern of activity when biting on the right.

The lower part of *Fig.* 3 is a bilateral recording from the same subject, this time from the posterior temporal and posterior masseter fibres. The first record shows the individual bite as before. The second and third records show the pattern during left and right bites respectively. The posterior temporal fibres are more active on the biting and recording side;

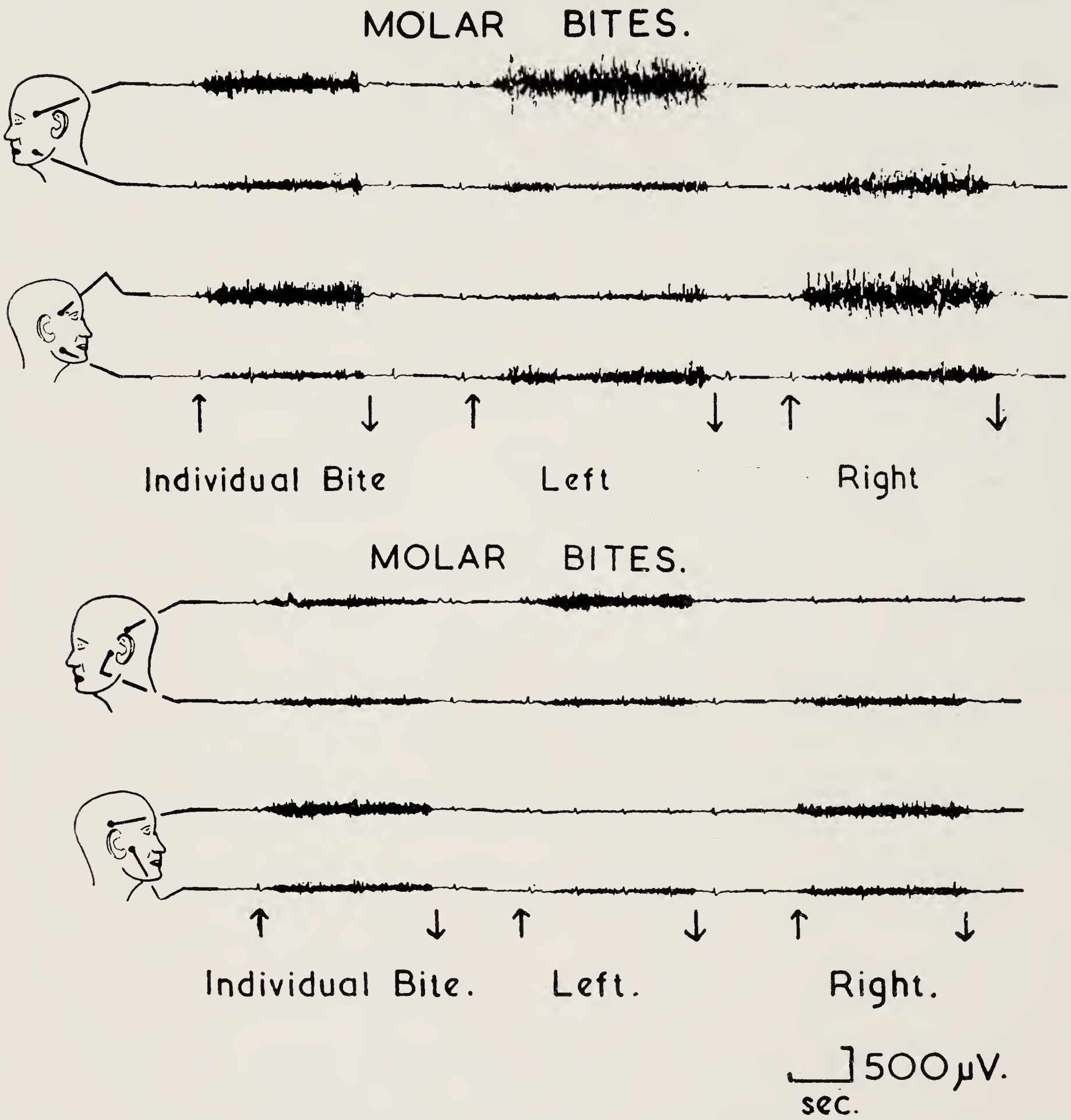


Fig. 3.—Activity recorded bilaterally during left and right molar biting. Individual bite on left for comparison.

while there is very little change in the posterior masseter fibres.

Fig. 4 is a unilateral recording from the left side. The first record shows the activity during protrusion of the mandible without contact of teeth. The diminished activity of both parts of the temporal muscle is apparent. The next two records show the change in this usual pattern of activity of the normal individual bite. The second record shows the change in the pattern of this activity during retrusion of the mandible without contact of teeth. There is a decrease in the activity of the anterior temporal and anterior masseter fibres. There is also an increase in the activity of the posterior temporal fibres, while there is

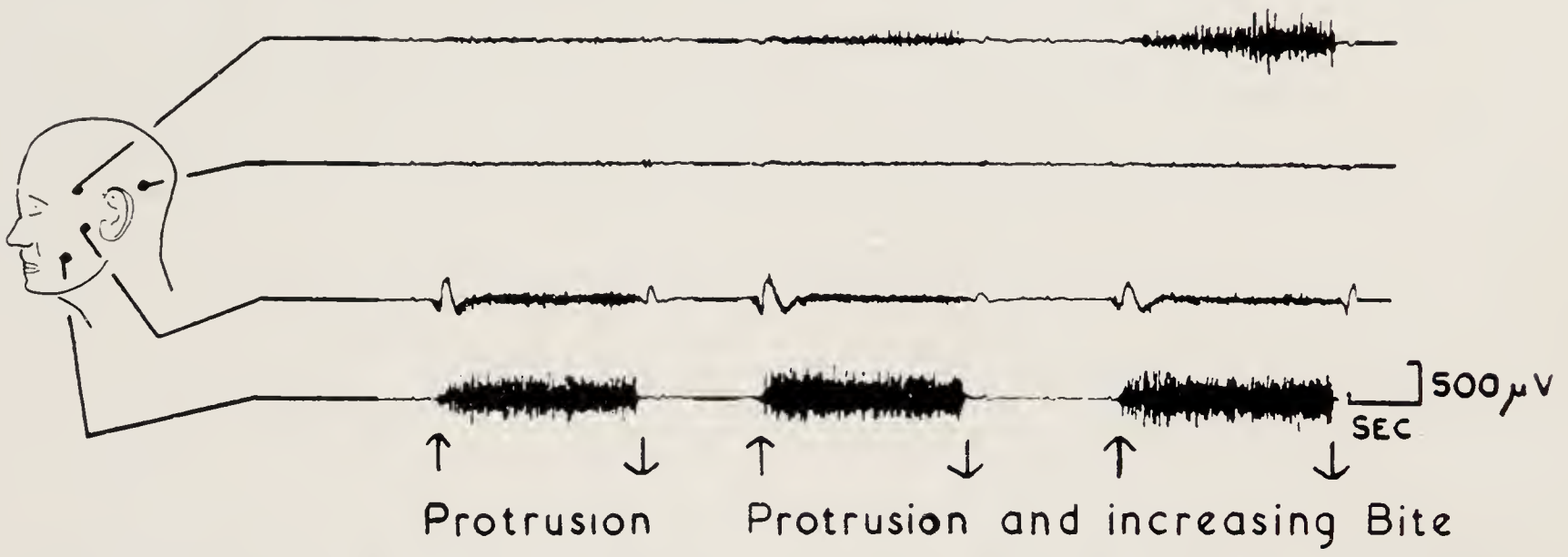


Fig. 4.—Activity during mandibular protrusion without occlusion, followed by protrusion with occlusion.

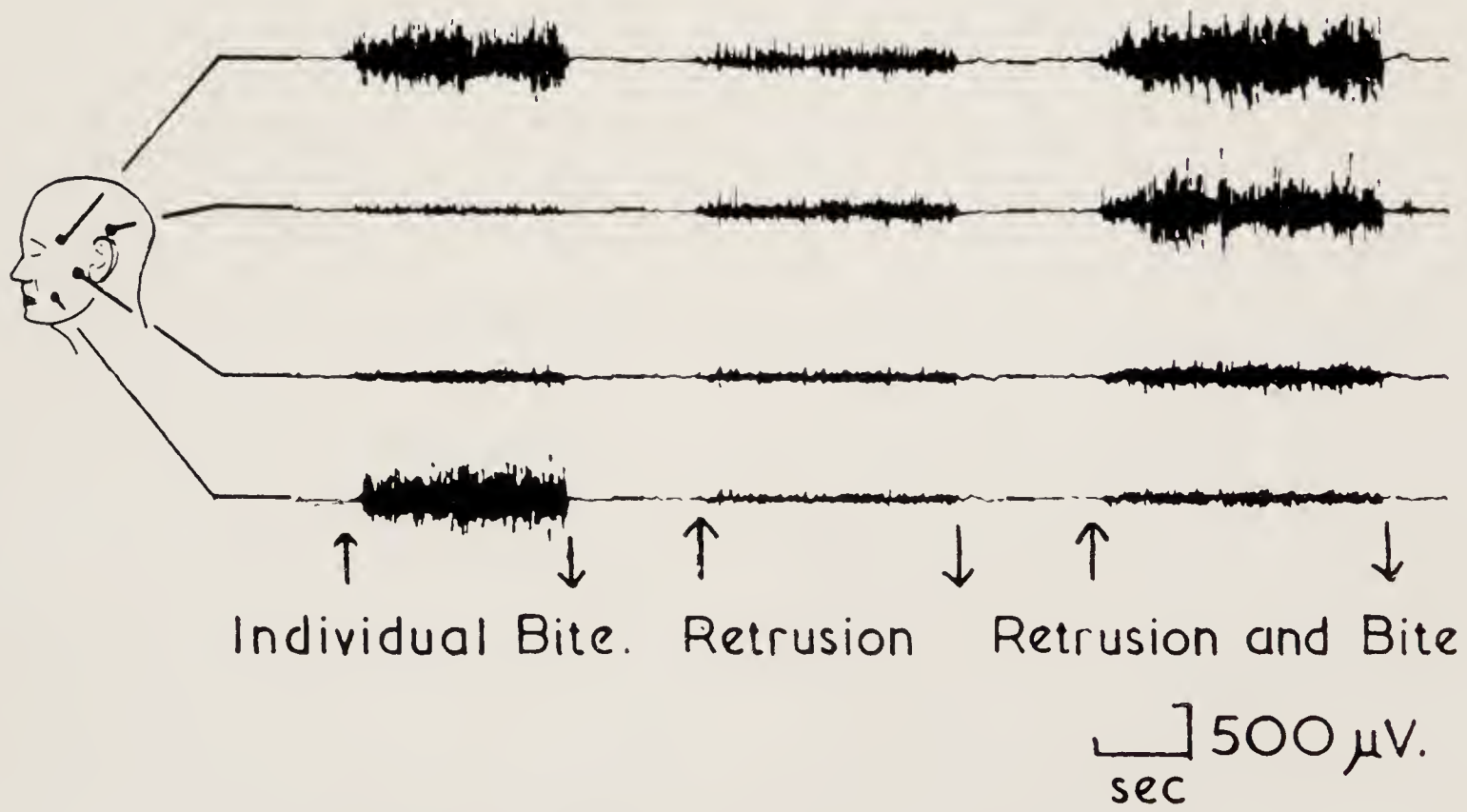


Fig. 5.—Activity during mandibular retrusion without occlusion, followed by retrusion with occlusion. Individual bite on left for comparison.

activity when the subject bites with the jaw in the protruded position. The main change takes place in the anterior temporal fibres, which show increasing activity with increased biting force. There is very little change in the activity of the masseter muscle.

Fig. 5 is again a unilateral recording from the left side. The record on the left shows the very little change in the activity of the posterior masseter fibres. On biting in this retruded position there is a further increase in the activity of the posterior temporal fibres; and a marked increase in the activity of the anterior temporal fibres. There is also increased activity of the posterior masseter fibres, these fibres now showing greater

activity than those in the anterior part of the muscle. This is the reverse of the situation shown in the individual bite.

These records show what I believe to be the fundamental pattern of reflex muscle co-ordination for the subject with normal occlusion; and such findings can be used as a basis for the study of cases of abnormal occlusion.

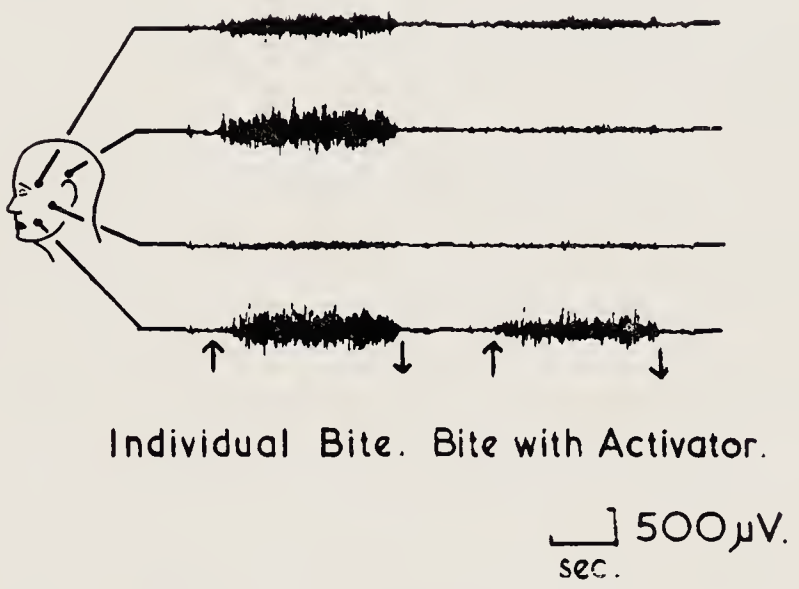


Fig. 6.—Activity during biting with and without activator.

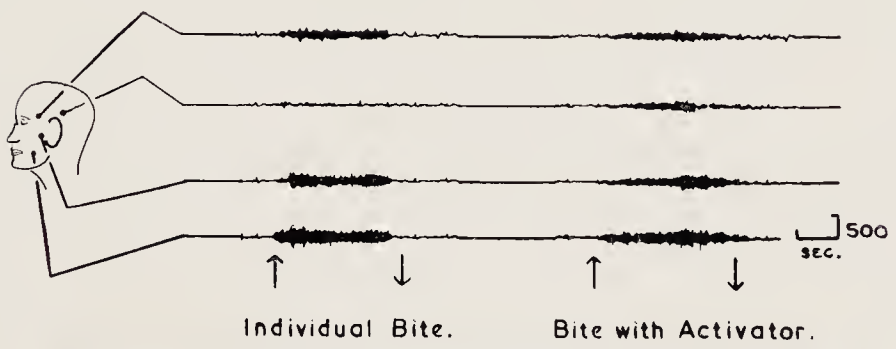


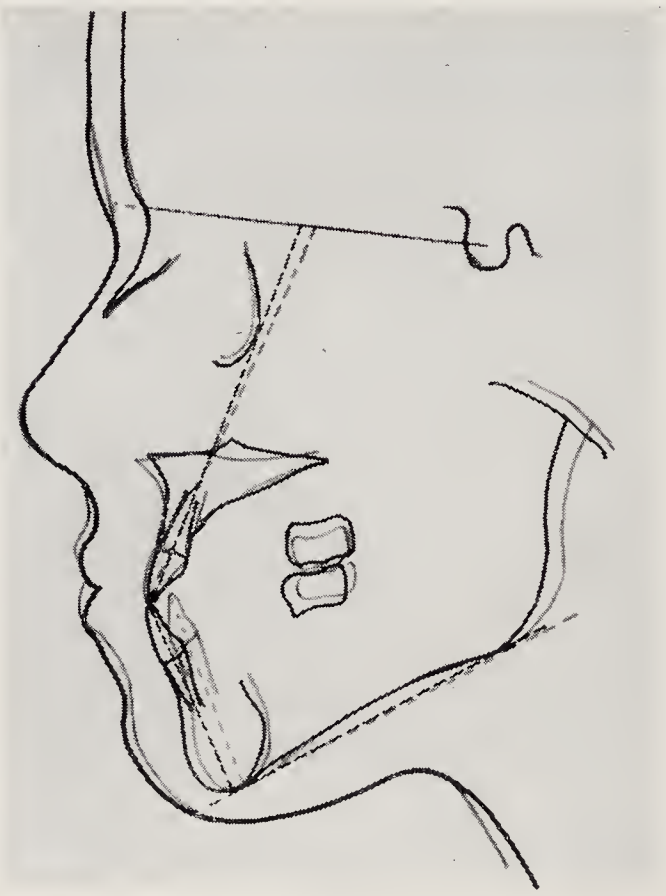
Fig. 7.—Class III case. Activity during biting with and without "sliding" activator.

STUDY OF ORTHODONTIC CASES

The investigation of orthodontic cases is a long-term procedure and is being undertaken in two ways:—

Firstly, cases are investigated before and during the course of treatment, in order to see whether or not changes in reflex co-ordination of the muscles takes place as a result of such treatment.

Secondly, cases whose treatment was completed before the start of this investigation have been examined, and will continue to be examined, for any changes that may take



A

B

Fig. 8.—*Case* 2159. Age $7\frac{9}{12}$. Angle Class III. Treatment with sliding activator from January, 1954 to June, 1954. A, Superimposed tracings of lateral radiographs. B, Models at commencement and on completion of treatment.

place in their present pattern. This will establish whether or not any such alterations persist.

A great many recordings of cases in these two situations have been made; and the following extracts from recordings of cases examined will show the trend of these investigations.

Patterns with Activators.—*Fig.* 6 is a unilateral recording from the left side of a patient with a Class II, division 1 malocclusion, studied in the course of treatment. On the left the record shows the individual bite.

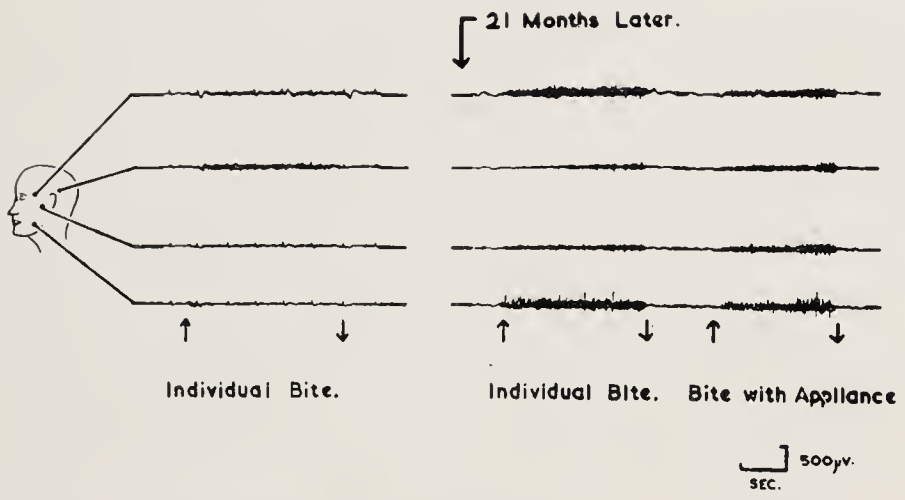
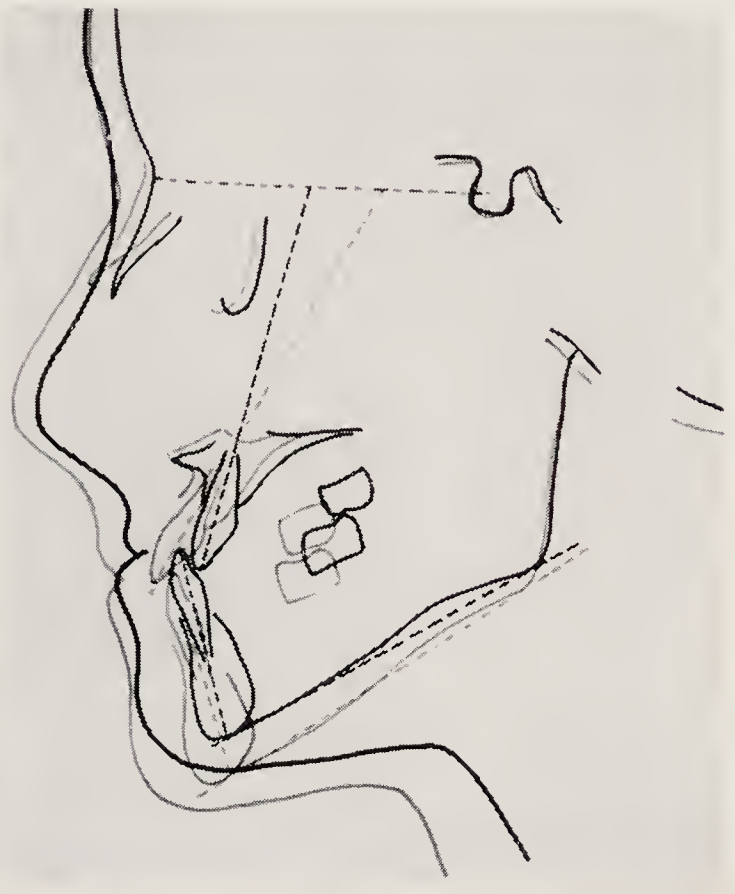


Fig. 9.—Same ease as in *Fig.* 8, showing ehanges in pattern during treatment.

The second record shows the activity when biting on the activator. The pattern of activity during individual biting differs from that seen in the previous normal subjects, especially in the temporal muscles. There is decreased activity in all the muscles when biting on the activator; and this is particularly marked in the posterior temporal fibres.

Fig. 7 is again a unilateral recording from the left side; this time of a patient with a Class III malocclusion.

The first record shows the individual bite. This again differs from the pattern shown in



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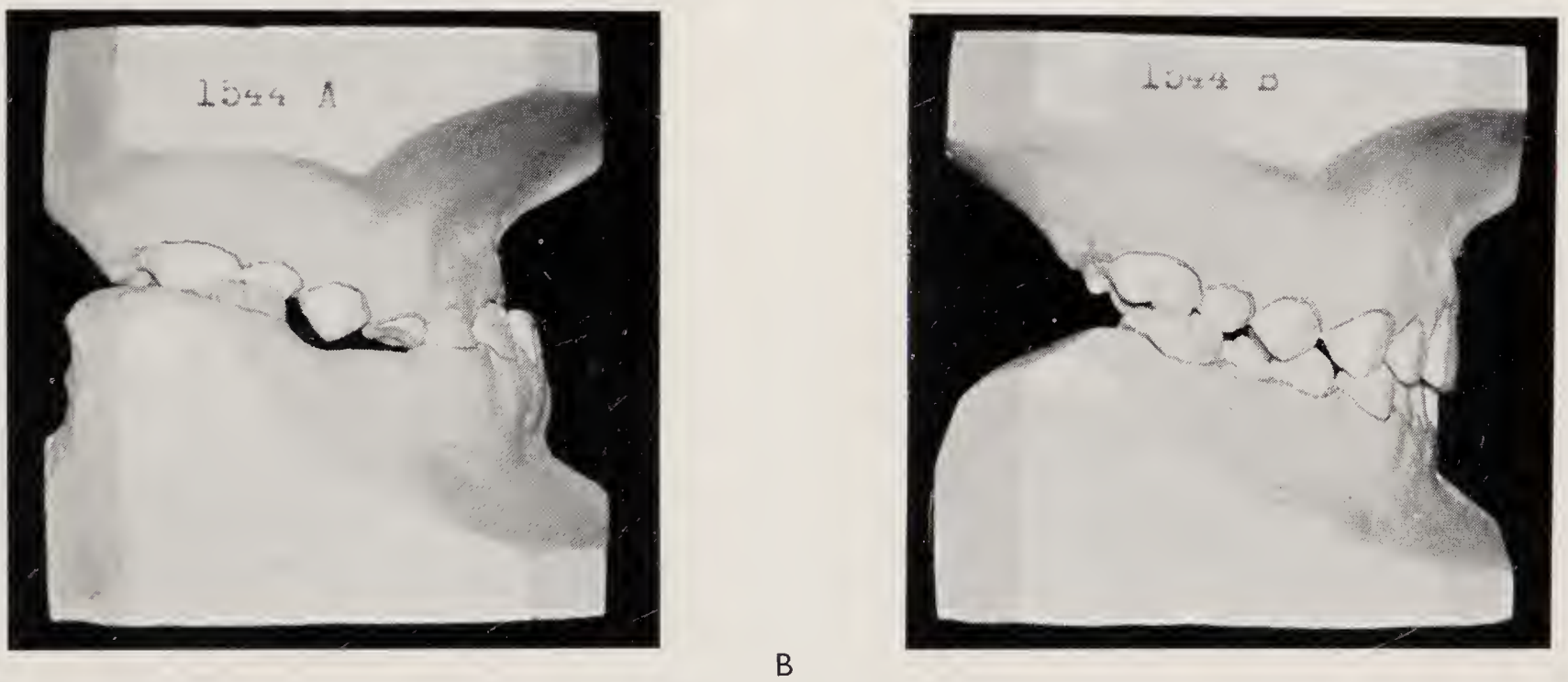

B

Fig. 10.—*Case* 1544. Age 9½. Angle Class III. Treatment with sliding aetivator from January 14, 1952 to February, 1954. A, Superimposed traeings of lateral radiographs. B, Models at eommeneement and eompletion of treatment.

The second record shows the activity when biting on the activator. The pattern of activity during individual biting differs from that seen in the previous normal subjects, especially in the temporal muscles. There is decreased activity in all the muscles when biting on the normal subjects, but this time in the masseter muscle. There is also asynchrony as shown by the early activity in the anterior masseter fibres in comparison with the other tracings. The second record shows the activity of the muscles when biting on a "sliding" activator.

The main change is the increased activity of the posterior temporal fibres and the now synchronous onset of activity in all the muscles including the posterior part of the masseter muscle.

The following extracts of recordings deal with cases referred to by Mr. Grossmann.

Case 2159 is a Class III malocclusion which has been treated since February, 1954, with a "sliding" activator (*Fig.* 8 A, B).

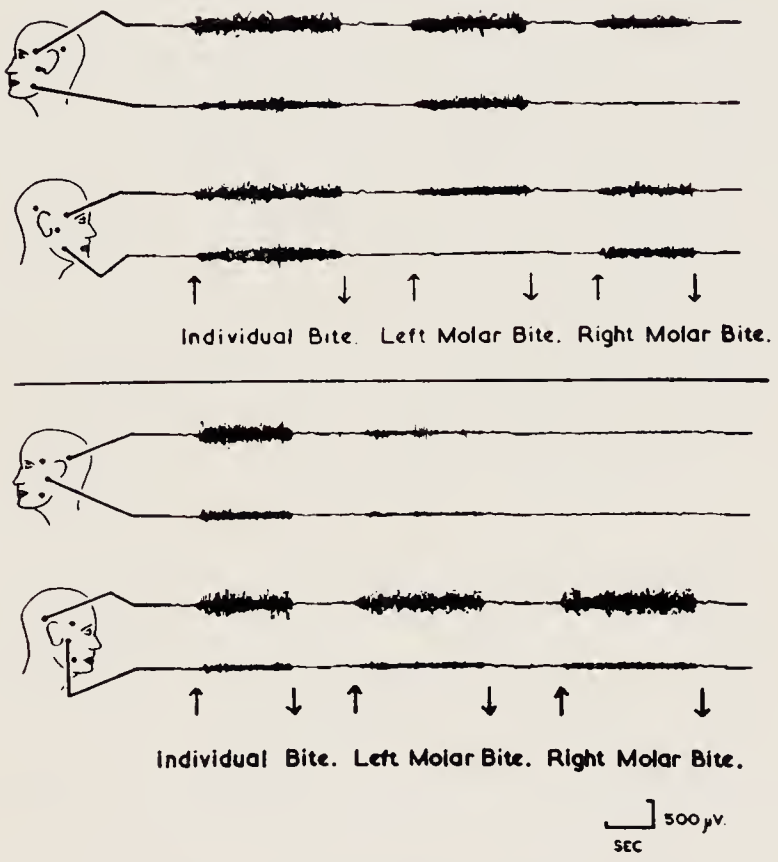

Fig. 11.—Same case as in *Fig.* 10. Compare with *Fig.* 3.

Fig. 9 is a unilateral recording from the left side. On the left the first record shows the individual bite as it was at the commencement of treatment two years ago. Electromyographically this is the typical picture of a Class III case biting on the incisor teeth, the outstanding feature being that the greater activity occurs in the posterior fibres of the temporal muscle.

The second record, taken 21 months later, shows a much more normal pattern; but the late build-up of activity in the posterior temporal fibres is not normal.

The third record shows the activity of the muscles when biting on the sliding activator used for treatment. This shows the now

A

B

Fig. 12.—*Case* 775. Age 11½. Angle Class II, division 1. Treatment with functional appliances from January, 1949, to December, 1953. Loss of right mandibular first molar. A, Superimposed tracings of lateral radiographs. B, Models at beginning of treatment, March, 1949, and at completion of treatment, December, 1953.

synchronous build-up of activity in all the muscles, in place of the abnormal asynchrony seen in the second record.

Case 1544 is a Class III malocclusion treated with a "sliding" activator (*Fig.* 10 A, B). This case has been examined on two occasions with an 18-months interval, and shows no change in the pattern of muscle

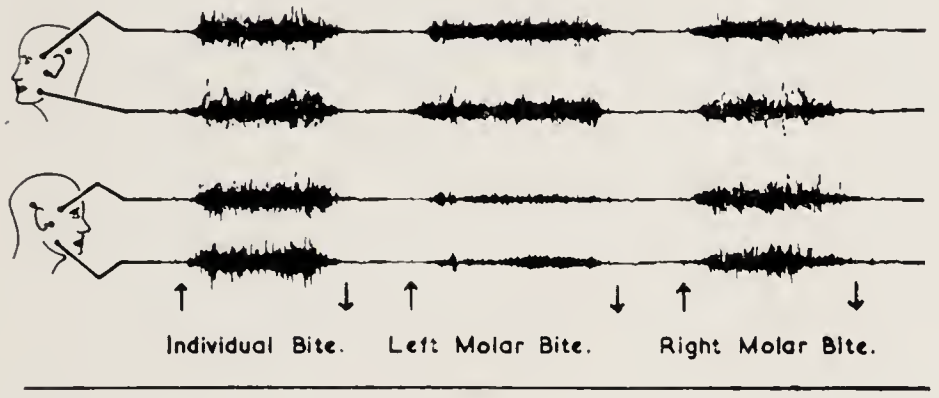

Fig. 13.—*Case* 775. Treated Class II, division 1. Compare with *Fig.* 3.

activity over this period. The occlusion shows a cross-bite on the right side; and a variety of patterns of muscular activity is produced on lateral biting. However, the patterns most frequently seen in this case are shown in *Fig.* 11. The upper and lower parts are not synchronous recordings. The upper part of the figure shows in the first record the individual bite, during which the right anterior masseter muscle shows greater activity than the left. The second and third records show the activity when biting on the left and right respectively; but the normal reversal of activity between the anterior masseter muscles is not shown by this case. In the lower part of *Fig.* 11 the individual bite shows normally co-ordinated muscle activity. The lateral bites seen in the second and third records do not show the normal patterns of activity, the right posterior temporal muscle being excessively active both on left and right biting; while there is only very moderate activity of the left posterior temporal muscle when biting on the left.

Case 775 (*Fig.* 12 A, B) is a Class II, division 1 malocclusion treated with an activator and examined after the completion of treatment. In the upper part of *Fig.* 13 the first record shows bilaterally symmetrical activity during the individual bite; but the slightly early

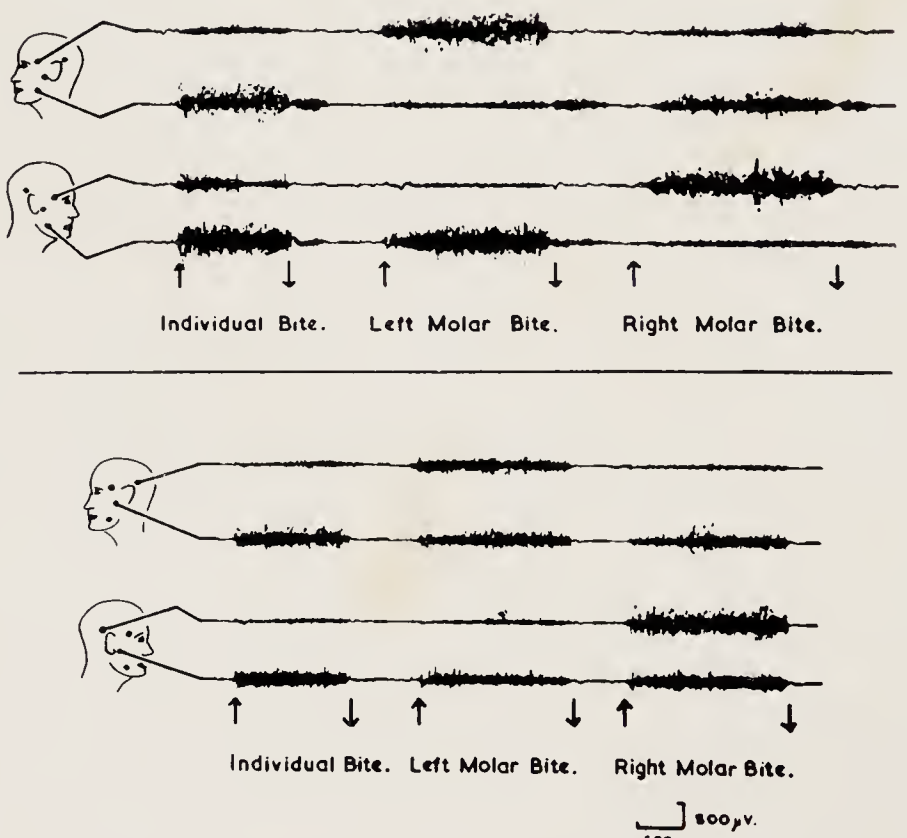

Fig. 14.—*Case* 1725. Treated Class II, division 1. Compare with *Fig.* 3.

activity of both anterior masseter muscles should be noted. In the second and third records similar early activity of the anterior masseter muscles is seen, this time on the side the subject is biting. This asynchronous activity differs from the normal pattern seen in left and right biting, as displayed earlier in this communication.

The first record in the lower part of *Fig.* 13 shows asymmetrically greater activity in the left posterior temporal muscle during the individual bite. The normal pattern when biting to the left is shown in the second record, but in the third record during biting to the right, the pattern of activity appears very similar to that of the individual bite.

The last case (1725) is again a Class II, division 1 malocclusion treated with an activator. The individual bite is shown in the first record in the upper part of *Fig.* 14. The pattern of muscular activity is normal,

except that the anterior temporal fibres show relatively less activity than is seen in a case of normal occlusion carrying out this movement. In addition, another abnormal feature is the burst of activity from the anterior masseter fibres, after completion of biting. The patterns of activity for the lateral bites shown in the second and third records are normal; and the anterior temporal fibres now show the usual considerable activity on the biting side. But again on completion of these movements a burst of activity is fired from the anterior masseter fibres.

The lower part of *Fig.* 14 shows a normal pattern of activity for the lateral bites in the second and third records; but in the first record, during the individual bite, the posterior temporal muscles show subnormal activity. Also, the onset of this activity occurs later in the movement. The occlusion would appear to be balanced; and although subnormal activity of the temporal muscles is evident during the individual bite, there is considerable activity in these muscles during lateral biting.

CONCLUSION

I would suggest that the examples I have shown are sufficient to indicate that this method of analysing muscular activity is beginning to give us an understanding of masticatory function, and that it is especially useful in determining the resultant patterns of co-ordination of the mandibular muscles at the completion of orthodontic treatment. It is also useful in determining, over a period, the stability of this end-result, and permits comparison of the progressive changes in co-ordination during treatment with the pattern of activity obtaining before treatment.

Whether or not the pattern of reflex co-ordination of the muscles investigated conforms to an arbitrary normal reflex pattern does not appear to be of great clinical importance. But I hope you agree that the evidence I have presented does establish one point quite clearly—and that is, that under appropriate circumstances marked changes in the pattern of reflex co-ordination of the masticatory muscles can be induced in human subjects. It will, however, be of interest to see whether these changed patterns of co-ordination remain constant in the cases whose treatment has been completed.

Acknowledgements.—I wish to thank Mr. W. Grossmann, M.D., Head of the Orthodontic Department of University College Hospital, for making available cases for investigation, and Mr. D. J. Timms, Registrar of this Department, for his assistance in selecting these cases. I am grateful to Professor David Slome for his continued support and direction of these investigations and for the facilities made available in his department at the Royal College of Surgeons of England. I very much appreciate the continued advice and assistance of Dr. B. D. Wyke, Senior Lecturer in the Department of Applied Physiology of the Royal College of Surgeons of England. My thanks are due to Mr. C. H. Redman for his patient assistance with the recording, for the photographic work carried out by him during the clinical investigations, and for the preparation of the slides for the lecture and the photographs for this paper.

Figs. 1–5 are reproduced by courtesy of the *British Dental Journal.*

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DISCUSSION

Mr. W. J. Tulley said that Mr. Grossmann had indeed shown treatment of some extreme cases where there would appear to have been a change of mandible/maxilla relationship and where the arches had been kept intact. This group of cases was not likely to alter the views of members, because even the most dogmatic among them had at some time obtained similar improvements.

He was not sure about the evidence of the X-ray tracings. He would like to have seen tracings of the rest as well as the occlusal positions before and after treatment, for he believed that in some of the Class II, division 1 cases where there had been a marked antero-posterior improvement, these cases originally postured forward at rest. The main point was that in these cases the oromuscular behaviour was fundamentally good.

He expressed his appreciation of the electromyographic research which Mr. Greenfield had briefly reviewed. It would require careful study before one could fully grasp it. For this reason, it was a pity that it had not been possible to publish the paper beforehand.

Mr. Tulley said he was well aware of the good work which had been done at the Royal College of Surgeons over the past five years or more in establishing the normal patterns of behaviour of the muscles of mastication. This was the first requirement. Mr. Greenfield would no doubt agree that his work on the abnormal function of these muscles arose initially from interest in bite rehabilitation which aimed at correcting occlusal disharmonies in a short time, either by grinding or by overlays. Electromyograms could thus be taken at fairly short intervals of time, showing how well the occlusion had been equilibrated. This work must go on, and more and more must come out of it. As Mr. Greenfield had said, the investigation of orthodontic cases was a very long-term procedure.

The application of Mr. Greenfield's methods to orthodontic work did not embrace the abnormal behaviour patterns of the orofacial muscles from a bucco-lingual aspect but was concerned purely at the moment with the muscles of mastication. The aspects of this research could be divided as follows: First, it could establish where an abnormal pattern of the mandibular elevators was produced by premature contact of teeth in reflex deviations in the path of closure. It could also show how the pattern changed with the activator in place. Secondly, the work on certain types of Class II, division 1 cases showed that in occlusion there appeared to be an inhibition of the activity of the posterior fibres of the temporalis. This suggested in some cases an habitual forward position of the mandible. He believed that most of these patients could bite back into a more retrusive position, and he would like Mr. Greenfield to verify this.

He was not sure that the evidence of the electromyograph could indicate that the end-result would be stable. It depended also on the activity of lips and tongue, which were likely to produce a relapse in axial inclinations of incisors.

He believed that most of the Class III cases shown had a degree of postural abnormality. In the true Class III cases which had been tested by the electromyograph, did Mr. Greenfield feel that the orthodontist was in danger of producing distal displacements encouraging increased activity of the posterior fibres of the temporalis?

Finally, he asked whether in using the monopolar electrode there was any pick-up of stray activity between the reference electrode and the monopolar electrode on the particular muscle.

Mr. C. F. Ballard said he was sure that both Mr. Grossmann and Mr. Greenfield would agree that their very important work was only a beginning. It was hard work, but it was worth while.

In the past it had been thought that environment had far too great an influence on the individual and that it was necessary only to modify the environment to be able, by means of treatment and appliances, to produce normal occlusions. Before orthodontists could know exactly what they could or could not do, they must realize that environment played very little part in producing malocclusions.

It was not only in orthodontics that this about-face was taking place. Orthopædic surgeons and people in the physical medicine world were now entirely changing their views and were accepting the fact that many of the things which in the past were regarded as abnormal were due to inherited characteristics, and neither training or exercises, nor force could change the pattern of the bones.

Mr. Grossmann had himself referred to athletics by way of illustration. In the world of athletic training, Mr. Geoffrey Dyson and other important people were now saying almost exactly the same thing. Mr. Dyson was now teaching that it was impossible to put into an individual more than he had inherited. An athlete could be trained to make the best of his inherited patterns, but if he did not possess world-beating activity it was no use training him for the Olympic Games.

If observations on soft-tissue behaviour were related electromyographically, it should be possible, in the light of the work of Moyers and of that by Mr. Greenfield and Dr. Wyke, which was to be published, to predict what the electromyographic recordings would show. From observations it should be possible to predict ordinary patterns of activity at rest in the posterior position and the activity from the true posterior position into occlusion. He had gained this impression after discussing with Mr. Greenfield cases which they had both seen treated at the Royal College. Nevertheless, Mr. Greenfield's work would help orthodontists to be certain of their clinical observations on soft-tissue activity.

Referring to the question of the gap behind the canine, he said that a high percentage of Class II, division 1 cases were treated by extraction. His own explanation was that if the case was a good one for treatment without extraction, it was because the reciprocal movement of the teeth was such that the upper teeth had to go back half a unit and the lower two teeth had to come forward half a unit.

When the cheek teeth were shifted back, the crowns were moved rather than the roots of the teeth, so that in the canine region the root of the canine remained in close proximity to the root of the first premolar but the canine crown could not drop back into the gap. In other words, to eliminate the gap it was necessary either to move the roots of the four distally or move the apex of the canine.

He had criticism to make of some of Mr. Grossmann's tracings. Speaking of two Class II, division 1 cases in particular, in which Mr. Grossmann showed a considerable change in dental base relationship as between before and after treatment, he thought there was no doubt that these two cases were postured forward, the reason being that the cheek teeth were not in occlusion. He was making these statements as a result of the mistakes that he had seen made.

At least a thousand or so treated cases had now been observed, and if a gap was seen between the cheek teeth in a lateral radiograph—supposedly taken in the true occlusive position—it was known that the person had postured forward on to the incisor teeth; and if that individual was asked to bite back and have another picture taken, it would not show the gaps between the cheek teeth. Mr. Grossmann had not shown condyle radiographs of these cases. If Mr. Grewcock had taken condyle radiographs of these pictures, it was fairly certain that he would not have fallen into the trap of taking condyle pictures with the mandible forward in that postured position.

He was not saying that the forward postural position was an undesirable feature or indicated a failure of treatment, but he thought that in many cases the

occlusion of the teeth was changed in such a way that new postural patterns were reflexly produced in the individual and could be reflexly maintained. He did not think that these cases would relapse, because the soft-tissue behaviour was favourable.

Those individuals preferred to maintain an anterior seal, and they would do so by keeping their lips closed across what would be an increased aperture, but they postured their mandibles forward to help them produce an anterior oral seal in the most comfortable way. They did it subconsciously.

These differences of approach indicated that what must be done in future was to be very careful in analysing cases, not from cephalometrics, which Mr. Grossmann had criticized, but from the point of view of patterns of activity. In the first analysis, the most important thing was the true postural position of the mandible in relation to the maxilla. This method would obviate falling into the error of assuming that some of the results were changes of posture centred on the central nervous system or changes of posture due to growth in the maxilla.

He wished that it had been possible to circulate the paper beforehand, to provide an opportunity of preparing fuller questions, for the importance of the subject merited careful study. He wished success to Mr. Greenfield and Mr. Grossmann in the next thousand cases they analysed.

Mr. R. Grewcock said that he had been privileged to take a very small part in the investigation. Being unversed in the mysteries and intricacies of orthodontics, he had approached the matter from this angle. The reason that Mr. Grossmann had not shown all the X-rays was that many of them were not sufficiently good to be shown as slides. He agreed, however, that more tracings might have been done, and for this he apologized.

He had taken mandibular joint X-rays of each side in rest positions and occlusion, and he was quite certain there was no question of any postural alteration of the mandible, either in the rest position, as Mr. Tulley suggested, or in occlusion, as suggested by Mr. Ballard. He felt sure that from rest position to occlusion was as near a pure hinge movement as could be found. It also firmly established to his satisfaction a normal condyle fossa relationship.

From a clinical point of view he had examined the gingivæ and these were normal also. In fact, they represented a surprisingly normal collection. He had examined their powers of closure to see whether they were what was badly termed truecentric but which he himself preferred to term centric. Of the 14 examined, 2 were slightly out of centric. There was a slight premature contact and a slight slew to one side during normal closure, which was easily put right.

Having examined the cases, he felt rather like the man who, on seeing a giraffe for the first time, said, "There is no such animal". He could not help feeling that the older one became, the less one could dogmatize about any branch of dentistry, and particularly orthodontics. The words of Samuel Johnson could aptly be used: "I dogmatise and am contradicted, and in this conflict of opinions and sentiments I find delight".

Professor G. E. M. Hallett suggested that if lateral skull radiographs were taken of a few normal cases—he was thinking of the occlusion—at the ages of, say, 10 and 11, and if one forgot about them for four or five years and then took fresh radiographs and compared them and superimposed them, the skull would not have grown very much, if at all, during that time. If they were superimposed on Nasion-Bolton, it would be found that in some cases the main growth had been in a downward and forward direction, in others almost wholly in a forward direction, and in others in a downward direction. They would have maintained almost perfect occlusion over that time. If the direction could be foreseen, this would help greatly.

In some of Mr. Grossmann's superimposed tracings he noticed that the main growth had been in a forward direction. In others it had been downward and forward, and in others wholly downward. This would contribute to the result in a natural way, quite apart from any treatment by orthodontists, whether by inter-maxillary traction or by any other form of therapy. Where the method worked, orthodontists would be gratified and would ascribe it largely to their treatment. Where it did not work, they might feel like putting it back into the cupboard.

He had noticed from time to time that although treatment was applied nothing seemed to happen, but that suddenly, between the ages of 12 and 14, a child might have a tremendous spurt in growth and results seemed to be achieved. Anyone who was fortunate in taking the skull radiograph at that time would probably find that the increase in growth was working with him, and would be gratified.

Recalling Poirot's words—"I only dressed him. It was God that killed him"—he suggested an adaptation for the orthodontist: "I only treated him. It was God who produced the finished result."

Mr. Tulley asked whether Mr. Grewcock had taken the temporomandibular joint X-rays only at the end of treatment. He did not wish to imply that there was any posterior abnormality then, but purely hinge movement in the slightly forward position.

The President, in concluding the discussion, said he was not surprised that no one else wished to contribute. There was so much in the paper needing intensive study that it was extremely difficult to discuss it without reading it beforehand. Like all pieces of original work, it would stand or fall by what happened as it was extended and when others tried to repeat it; for all work must be repeatable to be of value. It would be very interesting to see what happened in future in the two schools of thought when the work, as undoubtedly it would be, was extended and repeated.

Mr. Greenfield and Mr. Grossmann were then invited to reply.

Mr. Greenfield, replying to the discussion, recalled the question by Mr. Tulley as to whether some of the cases were postured back. Most people could posture back and bite in a slightly distal position, but in these cases it was only very slight distal biting. This could be seen from the electromyogram. If after orthodontic treatment the patient on biting showed what was considered a more or less normal electromyographic pattern, and if the patient was then told to attempt to bite in a distal position and no change in the masseteric pattern was observed, apart from perhaps increased posterior temporal activity, then it could be said that the bite first given by the patient was a forward bite; but if the patient had the bite of a normal individual the attempted distal bite would show the 'reversal' activity of the masseter muscle.

I repeat, therefore, that if no relative change of activity of the two parts of the masseter muscle was seen the mandible was not postured back, and most

likely started from a postured forward position. If the aetivity of the anterior masseter deereased and the posterior masseter showed a relative inerease in aetivity, the mandible was in a postured baek position and started from a more forward postured position. He did not quite understand the question about the Class III eases.

Mr. Tulley: 'You said that when they were treated, you got a eontraetion of the posterior fibres of the temporalis.'

Mr. Greenfield replied that that was what he had said, not to-day, but on other oeeasions. Some of the eases showed it after treatment. One ease had shown it eighteen months ago but after subsequent examination it no longer showed it.

Referring to monopolar eleetrodes, he said that the aetivity was from the region of the reeording eleetrode and not from the reference electrode; if, however, aetivity did oeeur from the region of the referenee eleetrode, it would appear in all ehannels and eould be easily deteeted and eould be ignored.

Although, as Mr. Ballard said, in some work the eleetromyographie findings might be predieted by eareful observation, it was not possible to tell whether a musele was eontraeting or not.

Mr. Grossmann, in reply, agreed entirely with Mr. Ballard that it was useless to train as an athlete someone who did not possess the right disposition.

Speaking of the forward tilting, almost out of oeelusion, of the molars in some of the traeings, he said he had omitted to mention that in two eases, after treatment was eompleted, first molars had to be extraeted, and a tilt of the seeond molar had oeeurred.

In reply to Professor Hallett, he agreed that the help of God was necessary if there were eases like the last one. Perhaps geneties would afford some help, but it would never be possible to assess the exaet result at the outset. The only thing to do, therefore, was to have faith.

The vote of thanks to Mr. Greenfield and Mr. Grossmann, proposed by the President, was carried by acclamation, and the meeting then terminated.

BACKWARD DISPLACEMENT OF THE PROXIMAL INTERPHALANGEAL JOINTS OF THE THIRD AND FOURTH FINGERS RESULTING FROM FINGER-SUCKING

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CASE REPORT

A GIRL of 13 years attended the Orthodontic Department of the Royal Dental Hospital with a history of persistent finger-sucking since infancy. Vigorous finger-sucking occurred at night, when excited, and during lessons at school. She fully realized the effect that this habit was having, but found it impossible to give up. *Fig.* 1 shows the finger-sucking position.

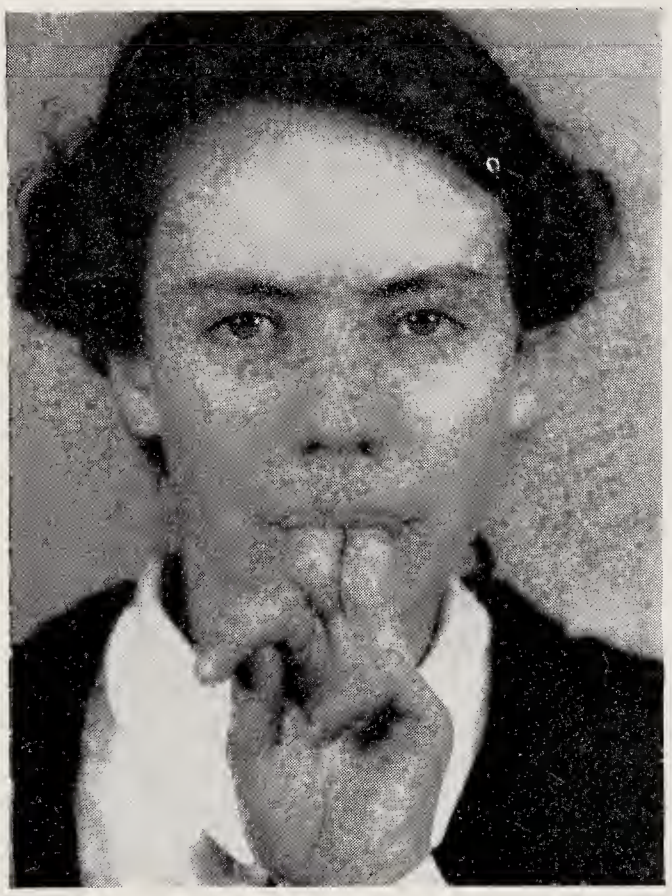

Fig. 1.—Showing finger-sucking position.

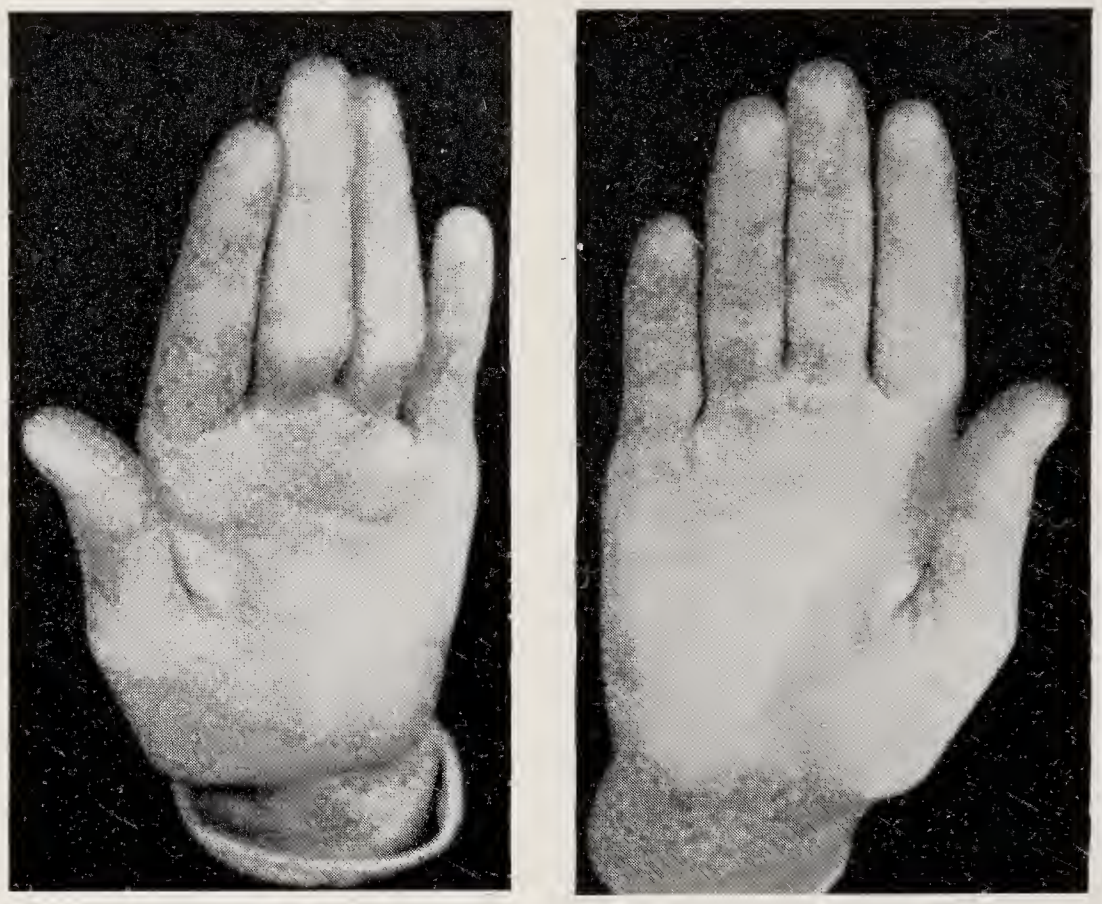

Fig. 2.—Comparisons of left and right hands.

The Hand.—The left hand showed hypermobility of first interphalangeal joints of the third and fourth fingers. Radiographs of the hand showed stretching of the joint capsules and hyperextension of the affected joints. There was protrusion of the distal articular surfaces of the proximal phalanges of the third and fourth fingers on to the ventral surface of the hand (*Figs.* 2, 3).

Physical examination showed no evidence of hypermobility of other joints.

The Orthodontic Condition.—Cephalometric assessment showed a Class II skeletal pattern (*Fig.* 4). The upper incisors were at a normal angle to the Frankfort plane. The lower incisors were retroclined on a low FM angle. The ocelusion was a mild Angle's Class II, division 1. There was no anterior open bite. (*Fig.* 5.)

Oral Muscular Behaviour.—Observation showed a normal tooth-together swallow with no evidenee of tongue thrust. The lips were habitually together. There was slight contraction of the mentalis muscle to maintain the competency (*Fig.* 6). The upper incisors were under control of the lower lip during swallowing.

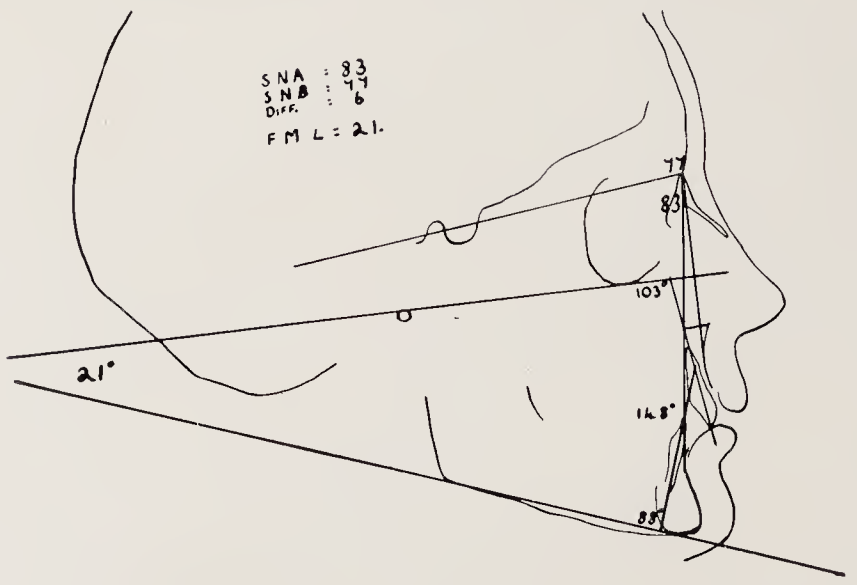

Fig. 4.—Tracing of cephalometric radiograph.

A short casual communication given at the meeting held on February 13, 1956.

DISCUSSION

Digital deformity caused by finger-sucking in infancy is not uncommon, but is usually of a temporary nature, the deformity correcting itself when the habit is given up. In the case presented the deformity is gross, the habit persists, and there is permanent stretching of the joint capsule.

Generalized hypermobility of joints does occur in certain rare general diseases. In cretinism laxity of the joints occurs. Fairbanks reports four cases of laxity of the finger-joints occurring in patients with chondro-osteodystrophy. The same authority reports cases of arachnodactyly or spider fingers, in which disease there is hypermobility of the digital

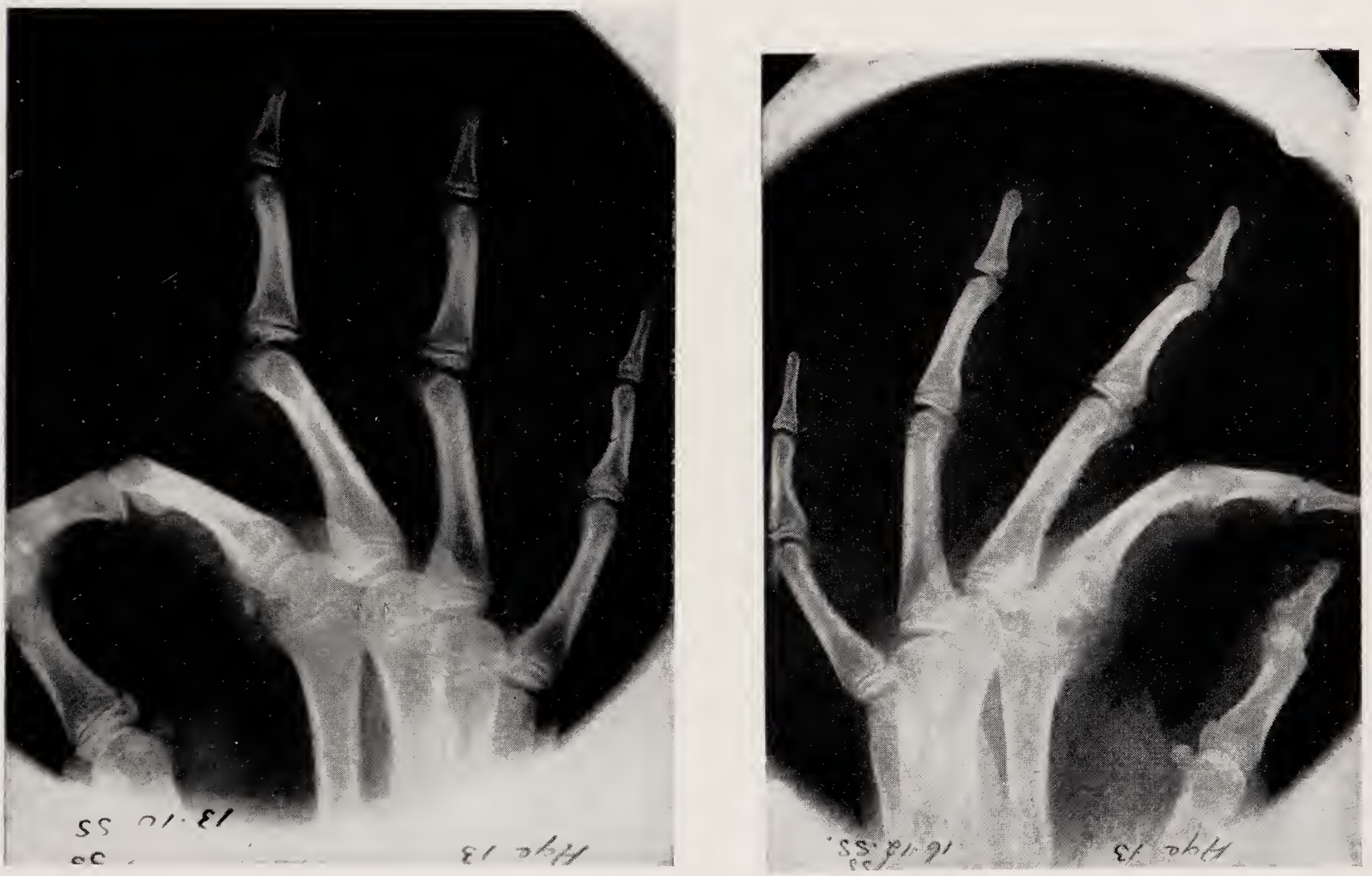

Fig. 3.—Comparison of radiographs of fingers.

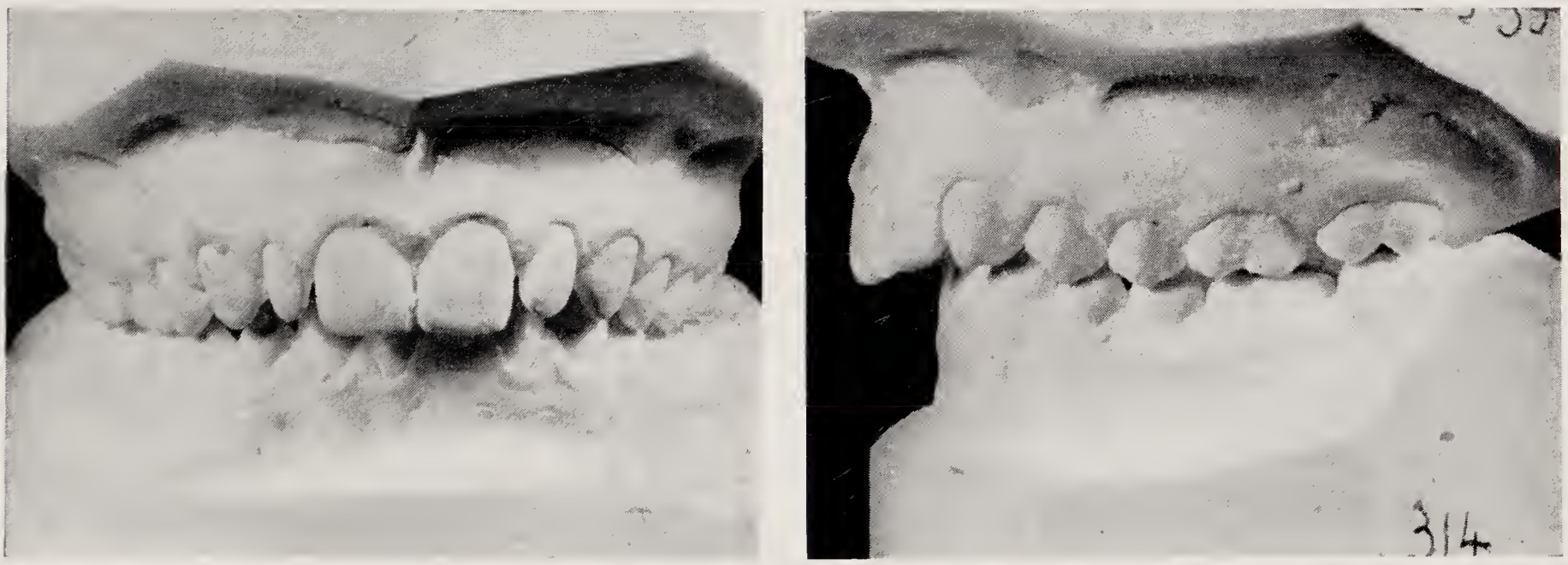

Fig. 5.—Models showing occlusion.

joints associated in 50 per cent of cases with dislocation of the lens in one or both eyes.

The damage to the joints in the case presented is probably permanent. Plastic surgery can offer a satisfactory repair, but only if the competent lips, and the fact that the upper incisors are under control of the lower lip.

Treatment with a monobloc appliance has not been successful. The patient would not tolerate the appliance, the sucking of fingers

Fig. 6.—Lip posture at rest.

habit is given up. Forcible restraint of the finger-sucking may result in a more disastrous habit forming. Mr. Walther has shown me a case in which forcible restraint of thumb-sucking resulted in nocturnal enuresis.

The minimal effect of finger-sucking on the teeth in the present case can be explained by the normal swallowing action, the potentially being preferred. It is hoped that the patient will soon outgrow this unfortunate habit, and then cosmetic surgery to the hand can be considered, and the malocclusion treated.

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ASPECTS OF THE TRANSITION FROM DECIDUOUS TO PERMANENT DENTITION

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BUCCAL SEGMENT OCCLUSAL CHANGES

This paper deals with the occlusal changes affecting buccal segment relationships which take place prior to and during the change-over from deciduous to permanent incisors. Other aspects of the change-over will be dealt with in a second paper.

The study of which this paper is a partial account was commenced in 1949 because there were problems in connexion with the relationship of permanent incisors on which the literature of orthodontics gave no satisfactory light.

The incisor group of permanent teeth has a significance for the orthodontist which marks it off from any other group in the dentition. The limits of space within which its members can arrange themselves are determined by the deciduous canines, which are not due for replacement until long after the establishment of the permanent incisors. Since the latter are always larger than the deciduous incisors, this makes them dependent for regular alinement on growth, and the timing of growth, to an extent which does not apply to any other teeth, except possibly the third molars. The space required, for instance, for the regular alinement of 3, 4, and 5 is always less than that occupied by c, d, e, their predecessors. Furthermore, the incisors always go through a stage of crowding before eruption, owing to their crowns achieving full size at an early stage of jaw growth. From the point of view of the practice of orthodontics, problems arise from the fact that malocclusions are most commonly seen when the full upper-lower incisor relationship has been established. The closeness of that relationship frequently creates an impression that it is due to the interaction of the two groups, but it is not established that this is the case. There is the alternative possibility that the malpositions which lead to the malocclusions of the teeth are established, wholly, or in part, before eruption.

It was decided, therefore, to study by means of serial recordings the period of development of the dentition during which replacement of deciduous incisors by permanent takes place. The study, however, was planned not as a test of any particular hypothesis, but as a systematic recording of all events in the dentition during the chosen period. Review of the literature made it seem unlikely that anything new would emerge relating to fields other than that of the incisor relationship, but in fact it was found that so much did emerge that it has been necessary to limit the account in this paper to the changes in the molar region.

THE LITERATURE

Delabarre (1819) described for the first time the spacing of the anterior deciduous teeth between 4 and 6 years, and suggested that the purpose was to make allowance for the permanent teeth. This concept still prevails among most writers of present-day text-books, e.g., Dewey Anderson, Korkhaus, McCoy, Salzmann, and Strang.

Kantorowicz (1926) was the first to emphasize the necessity for a genetic approach to the classification of dentofacial and occlusal anomalies on the basis of a large number of serial models of development.

Schwarz (1931) reported an anatomical study of the problem. He accounted for occlusal adjustment by means of tooth morphology.

Friel (1926) published his classical work *Occlusion, Observations on its Development from Infancy to Old Age*, and in 1954 *The Development of Ideal Occlusion of the Gum Pads and the Teeth*. His theory of the development of ideal occlusion has been widely accepted and

Given at the meeting held on March 12, 1956.

taught, though questioned by many orthodontists. The changes which he found taking place after the complete eruption of the deciduous teeth and before the complete eruption of the permanent teeth were:—

"1. Slight forward growth of the anterior portion of the mandibular deciduous arch, but mainly lateral growth of the whole arch to accommodate the mandibular permanent incisors.

"2. Slight forward growth of the anterior portion of the maxillary deciduous arch, but mainly lateral growth of whole arch to accommodate the maxillary permanent incisors.

"3. Forward growth of whole mandibular arch to compensate for greater increase in size of maxillary arch.

"4. Labial inclination of permanent incisors, especially the maxillary incisors.

"5. Forward movement of maxillary and mandibular first permanent molars after the loss of the second deciduous molars."

His diagram showing the five stages of ideal occlusion from 3 years of age show that at 3 years the distal surfaces of the second deciduous molars are in the same vertical plane. Between 3 and 6 years the mandibular arch has moved forward in relation to the maxillary arch, so that when the first permanent molars erupt, the point of the medio-buccal cusp of the maxillary molar comes into occlusion slightly mesial to the buccal groove of the mandibular first permanent molar. Later when the premolars replace the deciduous molars, the lower first permanent molar again moves forward into the extra space provided by the greater discrepancy between $\overline{543}$ and $\overline{edc}$, than between $\underline{543}$ and $\underline{edc}$ so that now the tip of the medio-buccal cusp of the upper tooth is opposite to the buccal groove of the lower. From then onwards, with cuspal wear, there is further forward movement of the lower arch, till the incisors may meet edge to edge.

Friel based his hypothesis on observation of cases of all ages over a long period and a detailed study of 214 chimpanzee skulls of different ages.

Lewis and Lehmann (1926) report the results of four-and-a-half years' observations of the width changes of the deciduous arches. Impressions were taken yearly for a number of children from the age of $2\frac{1}{2}$ years.

They found that "the functional points of the permanent series, as described by Hellman, hold for the deciduous series with only a few slight variations. Not one case out of 106 agreed *in toto* with the ideal scheme as advanced by Friel. Variation is the rule in occlusion of the deciduous series. In some cases there was a decrease in the overbite, especially noticeable at the time of eruption of the first permanent molars, except where there was a Class II, division 1 tendency. The deep overbite in those cases did not change. In general, as the incisors and canines showed attrition, a change occurred in the overbite relation. This change is due more to a forward growth, or drifting of the mandible, and sometimes of the teeth themselves, than to growth in a vertical direction. The occlusion at 5 was the same as at 3. The greatest change in occlusion seems to occur immediately before or immediately after the eruption of the first permanent molars and affects the overbite in the anterior region. The greatest increase in width of the arches occurs after the age of 6 years and is in the upper canine region. Measurements of the deciduous teeth offer no solution in diagnosing malocclusion. To predict the outcome of the permanent dentition from the deciduous is hazardous."

In 1932 Lewis and Lehmann published "A Quantitative Study of the Relation between Certain Factors in the Development of the Dental Arch and the Occlusion of the Teeth". The material comprises a series of models of 75 children taken once yearly for 8 years.

At the beginning the full complement of the deciduous teeth is present, and in the last all the permanent teeth except the third molars.

"We were interested, first of all, in determining whether or not there was a positive correlation between the combined diameters of the deciduous incisors and those of the succeeding permanent incisors. Could the size of the permanent incisors be predicted with any degree of accuracy from that of the deciduous incisors? (Northcroft stated that there is a direct relation between the two

sizes.) Though we found a fairly high correlation between the combined diameters of the deciduous and of the permanent incisors, the findings showed that the variability was great and the measurements of the 'deciduous' incisors are of little value as an index of the size of the permanent incisors. We found that the alinement of the permanent incisors cannot be predicted from that of the deciduous incisors. Also that spacing and alinement appear to bear little relation to one another, though there are more good alinements in the 'wide spacing' group. It is evident that other growth factors than wide spacing are of the utmost importance in determining the alinement of the permanent incisors. Bogue's method of using certain palate measurements as an index of developing malocclusion we found to be unsound. The diameter of the deciduous incisors appears to bear some relation to their spacing, the smaller the diameter, the greater the spacing (also confirmed by Lundstrom). The alinement of the permanent teeth cannot be forecast accurately on the basis of the relation between intercanine growth and the difference in diameter between deciduous and permanent incisors. The incidence of malocclusion increases as the dentition passes to the mixed stage. Sometimes it changes to normal and one type may change to another type."

They stress the need for further observations over a period of time—more and more investigations along similar lines and more observational methods.

Frederick Neumann (1931) in Bonn had a series of 44 cases. His results differed somewhat from those of Lewis. He seemed to be interested mainly in the spacing of the deciduous teeth and the correlation between this spacing and positions of the permanent incisors.

He concluded: "that developmental spaces only occurred where there was a large difference between the widths of the deciduous and the permanent incisors. When spaces were missing it often happened that the permanent incisors came into their normal positions. The size of the frontal growth of the jaw depended upon the need for space, i.e., differences in the total width of deciduous and permanent incisors. These widths were related to each other. When the difference in widths was large, the natural growth in width and length of the jaws began earlier and gave rise to spacing between the deciduous incisors. A physiologic spacing of the deciduous incisors, therefore, meant a large difference in the width of the deciduous and permanent incisors."

Clinch and Sillman were the first to present developmental series of dentitions from birth.

Clinch (1940) showed serial models of two cases between birth and 4 years. In one case she found that "at birth the lower gum pad is very slightly lingual to the upper. The first models at $1\frac{1}{2}$ years show an increased incisal overbite, at $2\frac{3}{4}$ years there was a slight reduction in the overbite, and at 4 years a considerable reduction. Occlusal views show that the lower arch has moved forward in relation to the upper arch. There was no increase of arch breadth or change in arch length."

In the other case: "The lower gum pad is well behind the upper at birth, but there is a vertical space in the incisor region. At $3\frac{1}{2}$ years there is normal occlusion of the deciduous molars." She attached great importance to the vertical space between the gum pads in the incisor region at birth. "The lack of space was a bar to further development of the mandible and the occlusion could not be normal at a later date. The changing arch relationship between birth and four years is also clearly shown."

In 1951 Clinch also published an analysis of serial models of children between 3 and 8 years. Models were taken of approximately 61 children at yearly intervals. This report deals principally with different measurements of the arches at the various stages of growth.

It was found that "the main increases in intercanine width take place during the time of eruption of the permanent incisors, and only slight increases were recorded over the rest of the period. Changes in the occlusion followed the description given by Friel—the lower deciduous molars move forward in relation to the uppers. These changes take place without a reduction in the size of spaces. (The largest space was 1·7 mm. whereas the

lower molar may move forward 4·5 mm. in relation to the upper.)"

Sillman (1948) had casts of 50 children from birth until 11 years. He thought that much could be done in preventive orthodontics if subtle departures from the normal could be recognized at an early age.

He found that "at birth there is no occlusion of the gum pads, and the mandibular pads are very much posterior to the maxillary pads. The mandible grows forward very quickly until with the eruption of the first deciduous molars, the relative antero-posterior relation of the jaws is definitely established, and the dental arches assume a relatively adult position.

"The horizontal overbite is thus reduced, while the vertical overbite, still pronounced, becomes less with the eruption of the molars and increased posterior alveolar growth. From $3\frac{1}{2}$–7 years there is relatively little change in the occlusion."

In 1950 Baume published his findings from the serial models of 60 children over a period of 8 years.

His conclusions were that "the deciduous models could be divided into those which had incisal spaces and those which had not. If there were no spaces when the teeth erupted, no spaces would occur between 3 and 6 years. The presence or absence of spaces is an hereditary factor—in identical twins both members are in either one or the other category.

"There were no changes in the occlusion during the period of the complete deciduous dentition; there was no mesial shift of the mandible, nor a forward adjustment of the lower teeth after the age of 4 years. When the deciduous dentition was completed at 3 years, the lower arch was already in a more forward position than the upper arch—there was a 'terminal step' in 14 per cent of cases. In 76 per cent the upper and lower arches ended on the same vertical plane (or straight). But one pattern did not develop from the other pattern.

"When there is no terminal step but the presence of 'primate spaces' (between $\overline{dc|cd}$) these spaces close on eruption of the first permanent molars. The lower buccal teeth thus drift forward and the first permanent molars establish normal occlusion.

"In those cases where there is no terminal step, the permanent molars erupt in a cusp/cusp relationship. This is only a temporary stage though, as the lower molars move forward more than the uppers after the change-over of the deciduous molars. This is the last adjusting mechanism of the permanent molar occlusion.

"The concept of a forward shift of the entire mandible, or the entire lower dental arch, is not borne out by facts. It is a matter purely of migration of the deciduous teeth, and the cause of migration is the pressure of eruption and root formation of the permanent molars. The 'canine axis' remains unaltered. Function and attrition have little bearing on the development of the dentition.

"With regard to the rate of lateral growth, the strongest growth impulse in the mandible is during the eruption of the permanent lateral incisors. The downward growth of the upper incisors is guided by the incisal edges of the lower incisors."

A special study of the overbite was made in 52 cases. He came to the conclusion that "no case with a severe deciduous overbite developed into a less severe permanent bite. There was a developmental tendency towards the formation of a deeper overbite (cf. Lewis). The degree of overbite depended primarily upon the amount of mandibular forward growth, which takes place at three different periods: (1) During the eruption of the deciduous canines; (2) During the eruption of the permanent incisors; (3) During the eruption of the permanent canines and premolars." [It is difficult to correlate this with his previous statement that there is no forward growth of the mandible after the age of 4 years.]

Moyers (1954) states that "Greek children living on coarse diets showed markedly altered occlusal relations between the ages of 3 and 6. This means that with primary tooth wear the normal growth of the mandibular bone may express itself in a more forward relationship to the upper face."

It can thus be seen that, though the amount of work which has been done in this field is very considerable, there is by no means complete

agreement on any of the different aspects of the development of the normal.

METHOD

The aim being to record, in a manner which would allow each stage in the transition from deciduous to permanent incisors to be reviewed comprehensively in comparison with its successors and predecessors, stone-plaster models were made from impressions of the teeth taken in zelex or parabar, as circumstances permitted.

In selecting the children, the only requirements were that the complete deciduous dentition should be present and that they should be available for inspections and impressions over a period of 5–6 years, or at least till the permanent incisors were fully erupted. (The latter requirement was the stumbling-block. Even with careful selection, there was a falling-away in the numbers.)

A number of the children were those of colleagues on the staff of the Royal Victoria Hospital, Belfast, some were private patients from town and country dental practices, others came from school clinics, and a good many were orphans from two orphanages in Belfast. The group thus has a claim to represent a good cross-section of the children of Northern Ireland.

Altogether there were 93 children; in 58 of whom there are records right through from the completed deciduous dentition to the full eruption of the permanent incisors.

Impressions were taken every six months during the period from the first shedding of a deciduous incisor to the completion of permanent incisor eruption, at other periods once yearly.

The fact that the impressions were taken more often during the active period of eruption of the incisors proved to be most valuable. Significant aspects of the eruption process would have been missed if a year had been allowed to elapse between the recordings.

Study of the changes taking place made it evident that it would have been more valuable if the occlusion at the completion of the deciduous dentition had been known. Most of the children were $4\frac{1}{2}$–$5\frac{1}{2}$ years at the beginning, only a few being 3–4 years. Miss L. M. Clinch, of London, very kindly made her series of models, 3–8 years, available. The evidence now presented is based on the study of the two series of models, which have been dealt with separately—Miss Clinch's series being studied to confirm, or otherwise, the results found on the Belfast models.

FINDINGS

Since variation in the pattern of development is the outstanding feature of my findings, I can best present them by listing the principal varieties of change, with the number of cases in which each occurred.

1. A forward relationship of the lower arch to the upper arch may be established at the completion of the deciduous dentition. Of the 21 cases of Miss Clinch's who were 3 years ± 5 months the distal borders of $\overline{E|E}$ were anterior to the distal borders of $\underline{E|E}$ in 15 cases—7 bilateral, 8 unilateral.

Of the 8 Belfast cases who were 3 years ±5 months, the distal borders of the $\overline{E|E}$ were anterior to those of $\underline{E|E}$ in 5 cases, all bilateral. (Baume found the percentage of his cases was 14.)

2. Forward movement of the lower arch relative to the upper may occur in the intact deciduous dentition.

Of the 52 cases of Miss Clinch's, the lower arch moved forward relative to the upper arch before the eruption of the first permanent molars in 13 cases—4 bilateral, 9 unilateral. (There was also forward movement in 10 cases to close spaces.)

Of 57 Belfast models there was forward movement of the lower arch at this stage in 9 cases—4 bilateral, 5 unilateral, with closure of spaces in 2 cases.

3. Forward movement of the lower arch relative to the upper may occur just prior to or during the eruption of the first permanent molars.

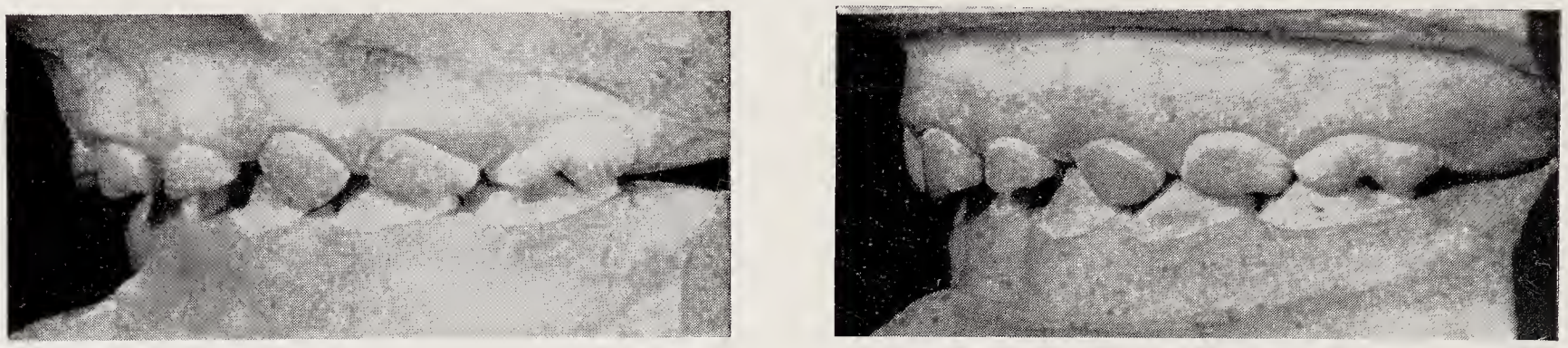
Of the 57 Belfast models there was forward movement of the lower arch at this stage in 15 cases—6 bilateral, 9 unilateral, with closure of spaces in 5 cases.

Of the 52 London models there was forward movement of the lower arch at this stage in

19 cases—5 bilateral, 14 unilateral, with closure of spaces in 11 cases.

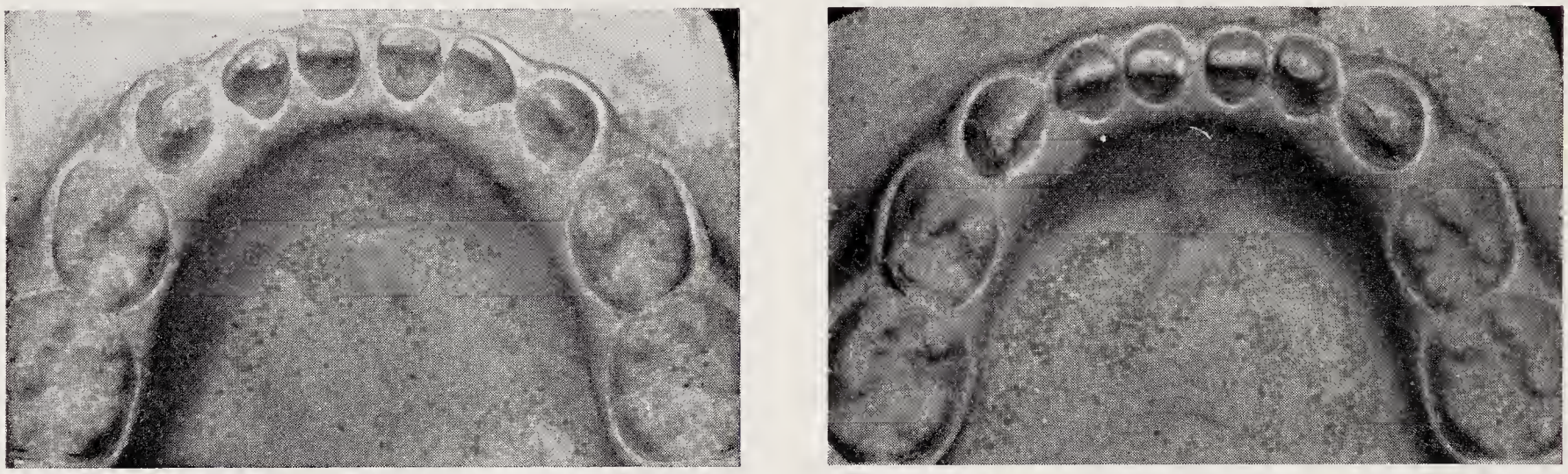
4. Forward movement of the lower arch relative to the upper may occur at the time of eruption of the lower permanent incisors.

1. Contrary to Baume's statement, it is seen that forward movement of the lower arch relative to the upper in the deciduous dentition does definitely take place, that the "canine axis," as he calls it, does change. This forward



A B

Fig. 1.—Forward movement of the lower arch relative to the upper between $3\frac{1}{2}$ and $4\frac{1}{2}$ years (A, B).



A B

Fig. 2.—Shows the lower occlusal views of A and B (*Fig.* 1). Note that though the space between $\overline{|CD}$ is reduced in B, the distance $\overline{|DE}$ have moved forward is much greater, and $\overline{|C}$ has also moved forward.

Of 48 Belfast models there was forward movement of the lower arch at this stage in 25 cases—12 bilateral, 13 unilateral.

Of 30 London models there was forward movement of the lower arch at this stage in 17 cases—7 bilateral, 10 unilateral.

5. There may be a difference in the behaviour of the buccal segments in the two sides.

In only 2 of the 57 Belfast models was there anything approaching symmetrical movement of the buccal segments on both sides.

6. No change in the arch relationship may occur up to the end of the period studied.

Of the 48 Belfast models there was no change in the arch relationship in 7 cases, and in 2 cases out of the 30 London models.

7. Changes in the arch relationship are most likely to take place in conjunction with eruption of teeth.

movement can be independent of the closure of spaces. Where there are spaces these are seen to be reduced, if not closed altogether, before or during the eruption of the first permanent molars. Often this closure of spaces is the first stage of forward movement of the lower buccal teeth, to be followed later by further movement of the whole buccal segment, or segments (*Figs.* 1, 2). *Fig.* 1 shows the left side occlusal views at $3\frac{1}{2}$ (A) and $4\frac{1}{2}$ years (B) respectively. Note the more forward relationship of $\overline{|CDE}$ to $\underline{|CDE}$ in B compared with A. *Fig.* 2 shows the lower occlusal views of A and B respectively above. It is seen that though the space $\overline{|C–D}$ is smaller in B than in A, the amount of the reduction would not, by itself, allow $\overline{|DE}$ to move as far forward. (*Table I.*)

2. *Marked forward movement of the lower arch at the time of eruption of the lower permanent*

incisors, and more especially the lower lateral incisors. This forward movement cannot be accounted for by the closure of spaces as in most of the cases where it took place there were no initial spaces to close. In some cases the forward movement of the lower arch at this stage is dramatic, being the first definite forward movement noted. In other cases, however, it is less pronounced, being one of a series of stages, the lower having moved forward also at earlier periods. (*Table II.*)

It is seen occurring in cases where an upper deciduous second molar has been lost, with consequent forward drifting of the upper first permanent molar. In spite of this, the lower first permanent molar moves farther forward, and not only the molar but the whole lower buccal segment on that side.

I have been unable to find any reference to forward movement of the lower arch at this stage in the literature. In one of Broadbent's radiographs, however, the occlusion of a child of approximately 6 years is shown—then again at 8 years. In the latter, when the upper and lower incisors have erupted it is seen that the forward movement of the lower has taken place. No comments were made.

Fig. 3 shows right and left side occlusal views at 6 years, when the first permanent molars have erupted (A and B) and later the right side at $8\frac{1}{2}$ years (C) and the left side at 9 years (D).

At the completion of the deciduous dentition the upper left buccal segment is well forward in relation to the lower segment, but on the right side the distal surfaces of the $\frac{E|}{\overline{E}|}$ end on the same vertical plane.

At 6 years (A) it is seen that $\frac{6|}{\overline{6}|}$ have erupted in the cusp/cusp relationship, while $\underline{|6}$ is fully one unit anterior to $\overline{|6}$ (B).

Table I.—Showing Number of Cases where there was Forward Movement of the Lower Arch Relative to the Upper during the Deciduous Dentition

Belfast Models
(Total, 57)

	Bilateral	*Unilateral*
a. Forward movement of lower arch before eruption of $\frac{6\|6}{6\|6}$	4 (+ 1 case to close spaces)	5 (+ 1 case to close spaces)
b. Forward movement of lower arch during eruption of $\frac{6\|6}{6\|6}$	6 (+ 3 cases to close spaces)	9 (+ 2 cases to close spaces)
c. Total no. where there was forward movement of lower arch in the deciduous dentition	10 (+ 4 cases to close spaces)	14 (+ 3 cases to close spaces)

It must be pointed out that the figures in (*a*) do not show a correct proportion, as in a good many cases there was only one deciduous model before the eruption of the first permanent molars, and in some the latter were beginning to erupt.

Miss Clinch's Models
(Total, 52)

	Bilateral	*Unilateral*
a. Forward movement of lower arch before eruption of $\frac{6\|6}{6\|6}$	4 (+7 cases to close spaces)	9 (+ 3 cases to close spaces)
b. Forward movement of lower arch during eruption of $\frac{6\|6}{6\|6}$	5 (+ 8 cases to close spaces)	14 (+ 3 cases to close spaces)
c. Total no. where there was forward movement of lower arch in the deciduous dentition	9 (+ 15 cases to close spaces)	23 (+ 6 cases to close spaces)

At $8\frac{1}{2}$ years (C) the lower right buccal segment has moved forward so that the mediobuccal cusp of $\underline{6}|$ is now just anterior to the buccal groove of $\overline{6}|$. The lower left buccal segment has been moving forward also, but it is not until 6 months later (D) that the mediobuccal cusp $|\underline{6}$ lies just anterior to the buccal groove $|\overline{6}$.

This case also illustrates the asymmetry of the two sides during development, yet normal occlusion is reached by both in the final models.

3. Difference in behaviour of the buccal segments on the two sides. It is seen that, even in cases where the relationship of the upper to the lower arch on both sides at the completion of the deciduous dentition is the same, and also when the permanent incisors have erupted, the ways by which the final occlusion is reached on the two sides may be very different. The buccal segments on one side may move forward at one stage, but the buccal segment (or segments) on the other side not till a later date, or perhaps not at all, e.g., often the normal molar relationship is established prior to or during the eruption of the first permanent molars on one side, while the first permanent molars on the other side erupt in the cusp/cusp relationship. When the lower incisors erupt then the latter relationship may be corrected.

Forward movement of the upper buccal segments may follow on a stage of forward movement of the lower buccal segments, even in cases where there is no sucking habit, and the lower then has to regain lost ground, before again getting to the fore. Often the lost ground is not regained and the upper arch then remains in a permanently forward relationship to the lower arch. There may be forward movement of the lower buccal segments on both sides at the same stage, but the degree of movement may vary, e.g., one side may move forward more than the other at one period, while the reverse takes place at a later period. It is the exception, rather than the rule, to

Table II.—Showing Number of Cases where there was Forward Movement of the Lower Arch Relative to the Upper during the Eruption of the Lower Permanent Incisors

Belfast Models

(Total, 58—4 were thumb-suckers and 6 had premature extractions of deciduous teeth which upset the occlusion. Therefore 48 where the occlusal changes were followed.)

	Bilateral	*Unilateral*
Number where there was forward movement of the lower arch during the eruption of the lower incisors	12	13
Therefore percentage where there was forward movement of the lower arch on one or both sides during the eruption of $\overline{21\|12}$	52·08 per cent	
Percentage where there was forward movement of the lower arch on both sides during the eruption of $\overline{21\|12}$	25 per cent	

Miss Clinch's Models

(Total, 52—22 had occlusion on both sides upset by premature extractions of deciduous teeth. Therefore the occlusal changes were followed in 30.)

	Bilateral	*Unilateral*
Number where the lower arch moved forward during the eruption of $\overline{21\|12}$	7	10
Therefore percentage where the lower arch moved forward during the eruption of $\overline{21\|12}$, on one or both sides	56·66 per cent	
Percentage where the lower arch moved forward during the eruption of $\overline{21\|12}$ on both sides	23·33 per cent	

find symmetrical movements taking placc on both sides to the same extent. One cannot therefore predict what the occlusion of the permanent dentition will be until all the deciduous tceth havc been replaced. (*See Fig.* 3.)

and the slight forward drift of all the upper and lower teeth due to approximal wear. Such movements are not bcing counted in this study.

These cases of what may bc called "static" relationship of upper to lower includc mal-occlusions, besides normal arch relationships.

Fig. 3.—Forward movement of the lower arch during the eruption of the permanent incisors. Note difference in the original occlusal relation, A on right, B on left. The final result is the same on both sides, C and D, C being attained 6 months before D.

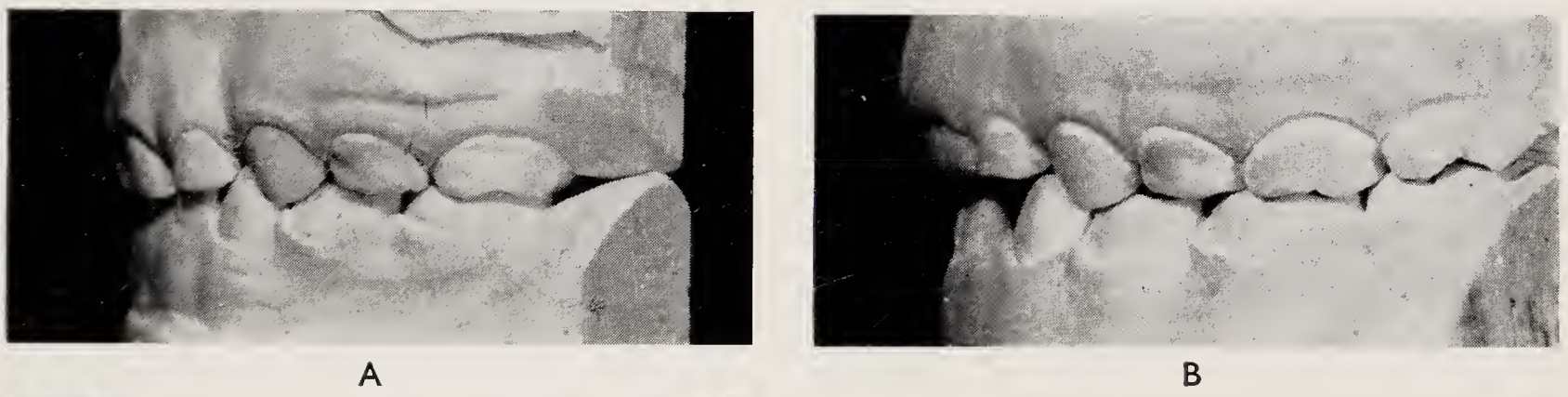


Fig. 4.—No change in buccal relationships at 5 and 8 years, A and B. In C loss of $\underline{|D}$ and drifting to reduce space account for the slight changes at 10 years.

4. The arch relationship, once established at the completion of the deciduous dentition, may change very little, if at all. There is, of course, always the forward drift of the first permanent molars whcn the premolars erupt

It is seen that a posterior relationship of the lower arch to the upper, established at the completion of the deciduous dentition, can remain of the same degree right through till all the permanent teeth are in occlusion (*Fig.* 4).

Fig. 4 shows the left side occlusal views of a child at 5 years (A), $8\frac{1}{2}$ years (B), and 10 years (C). In A the distal border of $\overline{|E}$ is well forward to the distal border of $\underline{|E}$. There is no change

when the first permanent molars erupt, or when the permanent incisors erupt (B). Unfortunately later there was premature extraction of $\underline{|D}$ with consequent drifting of the adjacent teeth. Had it not been for this it is likely that the relationship in C would have been the same as in B.

5. Forward movement of the lower arch takes place *principally* at the times of eruption of teeth. There are three main stages:—

a. Immediately prior to and during the eruption of the deciduous molars.

incisors. As evidence of (1) I am relying at the moment on the work done by Miss Clinch and Sillman and the fact that such a high proportion of the models, taken at 3 years, show that the lower arch is already in a forward relationship to the upper at the completion of the deciduous dentition. (*Table III.*)

Sillman (1948) in his records of children from birth to 11 years found that at birth the lower gum pads were very much posterior to the upper gum pads (approximately 4 mm.). When the lower deciduous incisors erupt the lower

Table III.—Showing Number of Cases where the Lower Arch was already in a Forward Relationship to the Upper Arch at the Completion of the Deciduous Dentition

Miss Clinch's Models
(21 Cases—3 years ± 5 months)

	Bilateral	*Unilateral*
Distal border of $\underline{E\|E}$ posterior to distal border of $\overline{E\|E}$	7	8
Distal borders of $\frac{E\|E}{E\|E}$ on same vertical plane	3	6
Distal border of $\underline{E\|E}$ more forward than $\overline{E\|E}$	2	4

Therefore terminal step at 3 years on one or both sides in 71·43 per cent
Terminal step at 3 years on both sides in 33·33 per cent
Therefore distal borders of $\frac{E|E}{E|E}$ on same vertical plane on one or both sides in 42·85 per cent
Distal borders of $\frac{E|E}{E|E}$ on same vertical plane on both sides 14·28 per cent

b. Immediately prior to and during the eruption of the first permanent molars.

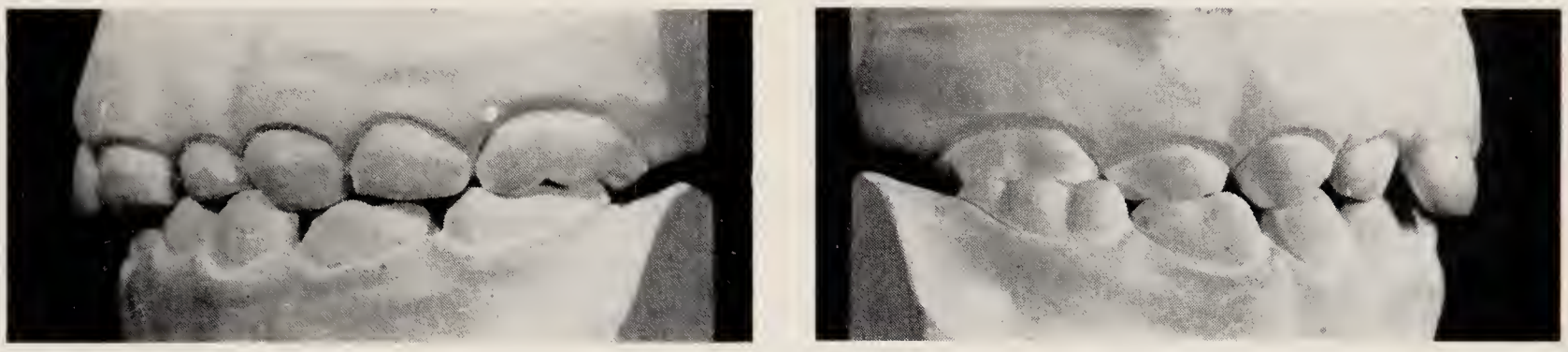
c. Immediately prior to and during the eruption of the lower permanent incisors and especially the lower lateral incisors.

In a small number of cases it is seen that the lower arch also moves forward between the completion of the deciduous dentition and the eruption of the first permanent molars, as described by Friel and Clinch. There is also the forward movement of the permanent molars that takes place following the eruption of the premolars, though this is more of a forward drift, using up the extra space. Clinical experience also supplies evidence of a forward tendency during the eruption of the third permanent molars. But the greatest impetus to forward growth of the lower arch seems to me to coincide with the times of eruption of the deciduous second molars, the first permanent molars, and the lower permanent pad came considerably forward, but with the eruption of the first deciduous molars, the dental arches assume a relatively adult relationship.

On studying the occlusion of the two cases (recorded from birth to 4 years) shown by Miss Clinch it is seen that the forward movement in one took place from $2\frac{9}{12}$–3 years, but there is no further forward movement at 4 years. In the other case there are models taken at 2, $2\frac{10}{12}$, and $3\frac{1}{2}$ years. At birth the lower gum pad is well behind the upper, but there was a vertical space in the incisor region. The lower has come forward between 2 and $2\frac{10}{12}$ years, but there is no further change between $2\frac{10}{12}$ and $3\frac{1}{2}$ years, i.e., after the eruption of the second deciduous molar.

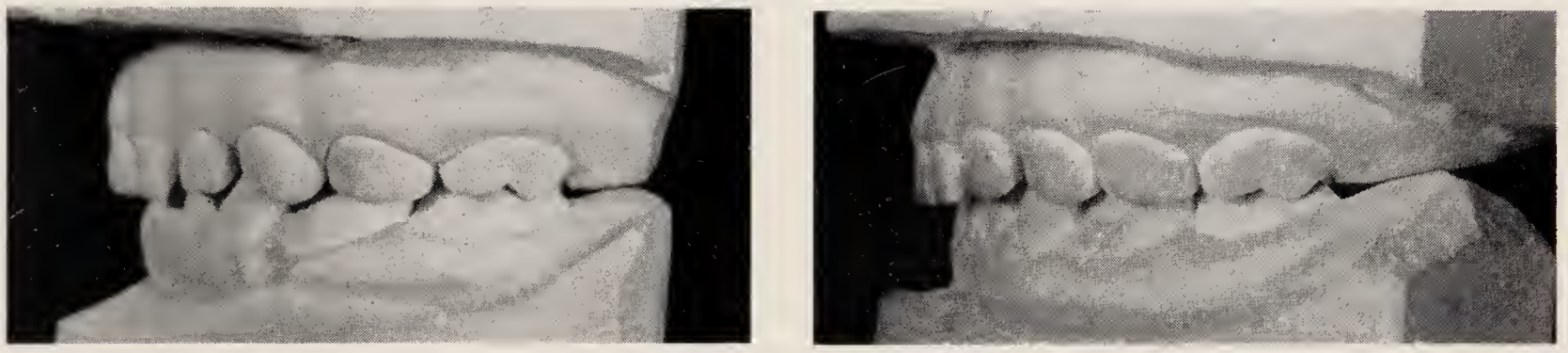
As Sillman found that there was a great forward growth of the lower arch during the times of eruption of the lower deciduous incisors and the lower first deciduous molars,

this would complete the picture of the stages by which the lower deciduous arch moves forwards from a very much posterior relationship to the upper arch at birth, to one where the distal surfaces of the lower deciduous second molars in the lower are already forward to those of the upper at the completion of the deciduous dentition. (*Figs.* 1, 5.)

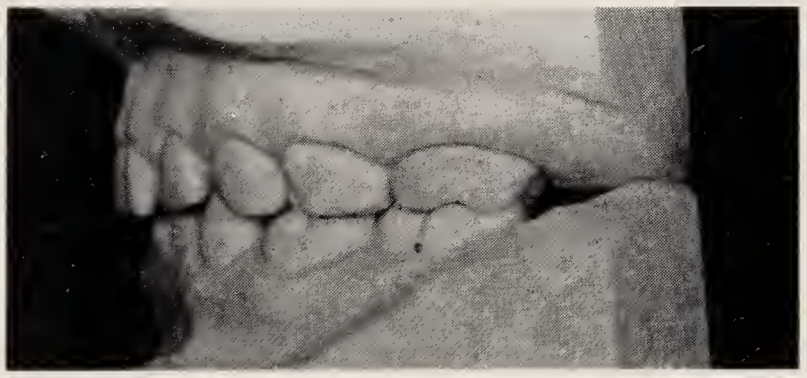


A B

Fig. 5.—Lower arch well forward to upper arch at 3 years. A, left, B, right, sides of same case.



A B



C

Fig. 6.—B shows forward movement of the left upper buccal segment between $4\frac{3}{4}$ years (A) and $5\frac{1}{2}$ years. When $\overline{|6}$ appears at approximately 6 years the lower left buccal segment has moved well forward again (C).

The forward movement taking place during the eruption of the first permanent molars is often not more than a forward drifting of the cheek teeth to close spaces, in those cases where spaces exist. Where, however, there are no spaces, a very definite forward movement of the lower arch may take place at this stage.

There is, alternatively, the tendency for the upper buccal segments to move forward relative to the lower at this period both in cases with and without spaces, and where there is no sucking habit to account for such movements. Forward movement of the lower arch at this stage, accompanied by an opening of the bite, was noted by Lewis and Lehmann (1926). (*Table II*, *Figs.* 6, 7.)

Fig. 6 shows the left side occlusal views of a case at $4\frac{1}{2}$ years, $5\frac{1}{2}$ years, and 6 years—A, B, and C respectively. In A it is seen that the distal border of $\underline{|E}$ is very slightly posterior to the distal border of $\overline{|E}$. In B the left upper buccal segment has moved forward so that now the distal border of $\underline{|E}$ is considerably anterior to that of $\overline{|E}$. In C $\overline{|6}$ is erupting, and it is seen that the lower buccal segment has moved well forward, so that now the distal border of $\underline{|E}$ is posterior to that of $\overline{|E}$, and $\left|\frac{6}{6}\right.$ can erupt into normal occlusion.

Fig. 7 shows the lower occlusal views of A, B, C, above. Note that the $\overline{D–C|C–D}$ spaces are reduced in B (when the left upper buccal segment has moved forward in relation to the lower), but there is no further reduction of these spaces in C, when the lower left buccal segment moved well forward in relation to the upper, on the eruption of $\overline{6|6}$.

DISCUSSION

When my findings on the changes which occur during development of the antero-posterior relationship of the arches which we regard as normal in the permanent dentition are collated with those of my predecessors in this field, it is obvious that there are discrepancies. Several possible reasons present themselves. It may be that there are in fact very wide variations in any population, and there may be great racial variations. The numbers dealt with by any observer are of course minute when considered as samples of the local population, and the geographical distribution of the groups so far recorded is wide. I find it difficult, however, to imagine that with larger samples we would find any substantial increase in the number of ways by which change of relationship can take place. The possibilities seem to be nearly exhausted in those recorded. Alternatively, it may be that certain changes which were observed by some and not by others failed to appear because of long intervals between recordings. Also it is possible that phenomena seen by some and not by others were not seen because they were not looked for. Whatever the reasons, it seems clear that it is too early to attempt any comprehensive statement as to what is the normal sequence of events leading to the establishment of normal occlusion. Professor Friel, pioneering in this field, has always emphasized that what he describes is to be regarded as the ideal occlusion, which implies that the steps recorded on the road to the adult occlusion are the ideal steps. Watching the very varied methods and timings which individual children have employed in achieving similar end-results, I find it impossible to frame a brief for any one pattern of development as "normal". As to "ideal", it would seem that to label a step in development as ideal involves a prediction. It is a statement that that step has a higher probability of leading ultimately to normal adult occlusion than has any alternative step. It is the case that on general grounds I would have predicted in some early stages that the normal would not be achieved, but I would have been wrong (*Fig.* 3). In other cases the same prediction would have been right. Clearly, very large samples would be necessary to provide a basis for a statistical prediction—if at all possible. On the present state of my knowledge I am less and less inclined to prediction. It is seen that any of the following can arise:—

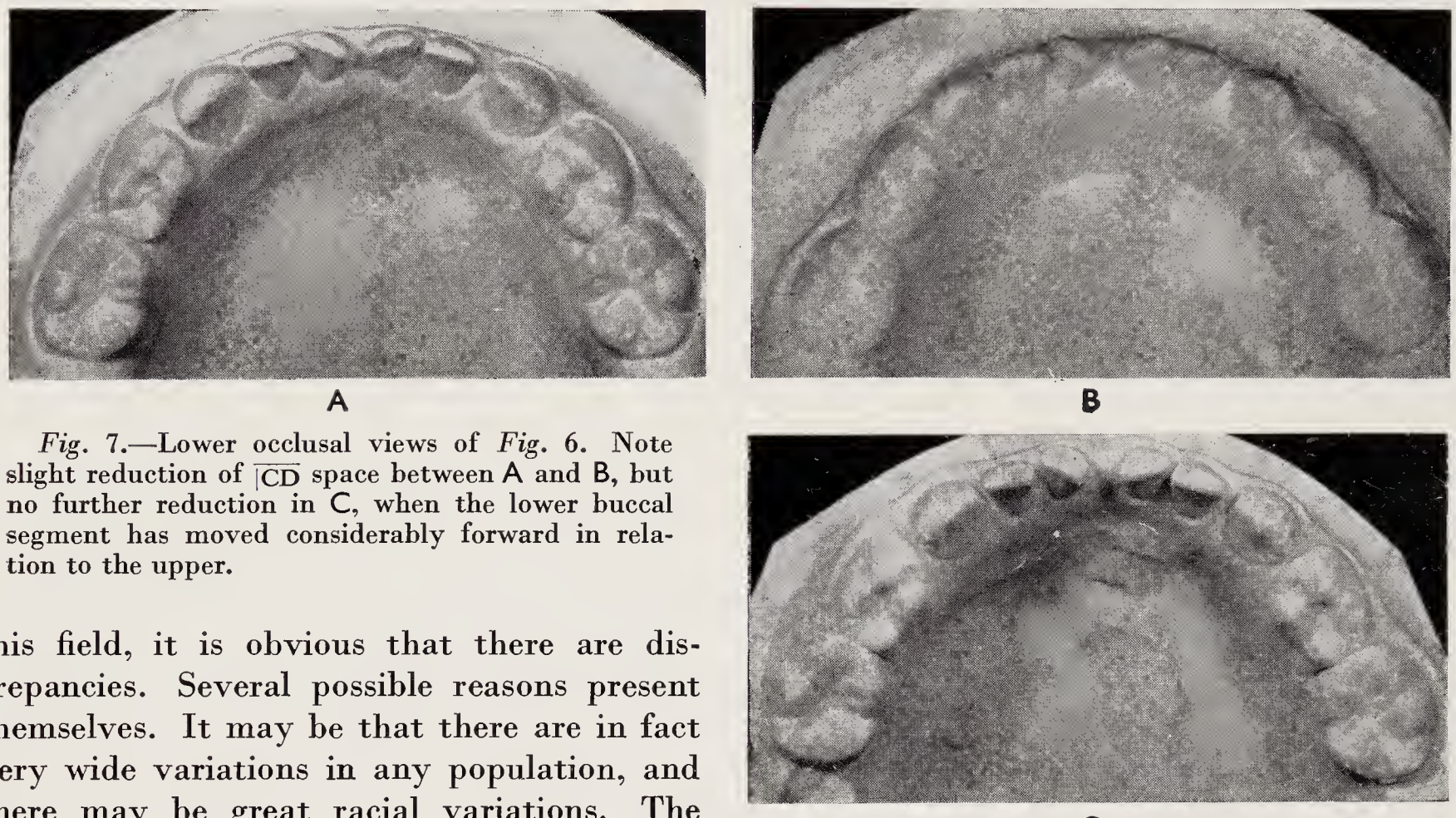


Fig. 7.—Lower occlusal views of *Fig.* 6. Note slight reduction of $\overline{|CD}$ space between A and B, but no further reduction in C, when the lower buccal segment has moved considerably forward in relation to the upper.

1. The normal relationship of the lower arch to the upper arch may be established at the completion of the deciduous dentition, negligible changes thereafter taking place. According to Sillman (1948), this position has been

reached from the very much distal relationship at birth, by a marked forward growth of the lower at the times of eruption of the lower deciduous incisors and the lower first deciduous molars. From a study of models of 2 of Clinch's cases, it is seen there is also a forward growth of the lower at the times of eruption of the second deciduous molars, but not immediately after that.

2. If the lower arch has not moved forward, as in (1), then it may do so before the first permanent molar is due to erupt. The stage is therefore set for the latter tooth, so that the tip of the medio-buccal cusp of the upper molar occludes slightly medial to the buccal groove of the lower molar.

3. Where the forward movement in (2) has not taken place, the lower teeth may move forward just prior to and during the eruption of the first permanent molars. The tip of the medio-buccal cusp of the upper tooth then, as before, occludes just medial to the buccal groove of the lower molar.

4. Where neither the forward movements of (2) nor (3) have taken place, so that the first permanent molars erupt in the cusp/cusp relationship, this may be only a transitory stage. The lower arch may move forward when the lower permanent incisors erupt so that the normal relationship is established then.

5. There is the forward drifting of the upper and lower permanent molars that takes place when the premolars erupt. As the lower moves a little more than the upper, final adjustments can then take place.

6. The upper and lower buccal segments on either side move independently of each other.

SUMMARY

The normal relationship of the lower arch to the upper arch may be established:—

1. At completion of deciduous dentition.
2. Before eruption of first permanent molars.
3. During eruption of first permanent molars.
4. During eruption of lower permanent incisors.
5. The final relationship may be reached in many ways, both sides, upper and lower, moving independently to one another.

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IMMEDIATE TORSION: A PRELIMINARY REPORT ON TWENTY-THREE CASES

By **Prof. G. E. M. HALLETT**

THE history of the surgical correction of single-rooted teeth goes back a long way. Fauchard and John Hunter and many others experimented with replantation, and transplantation of vital teeth was not at all uncommon. However, on occasion more than the tooth was transplanted to the discomfort of both patient and operator, and the application of transplantation fell into disuse.

In 1865 in a letter from John Tomes to a Dr. McQuillen of Philadelphia Tomes commented on the fact that he had noticed little in American publications of an operation which is "now becoming common in England, the twisting of teeth in their sockets then and there with a pair of forceps for the purpose of correcting irregularity of position". He goes on to say: "I have frequently performed this operation in children up to the age even of 13 years, sometimes operating upon 2 teeth on the same occasion and up to the present time I have not lost a tooth."

In 1881 Coleman refers to the rotation of teeth, or immediate torsion, and protests against the practice of this method on the grounds that the tooth is liable to lose its vitality. He was evidently prejudiced against this form of treatment, having as he says "recently removed a necrosed right upper lateral tooth which had been thus rotated; yet the eminence of the operator was a guarantee that the operation had been most carefully performed". He goes on to say that the tooth had never come down to proper length, was dark in colour, and more than half of it was resorbed.

Towards the turn of the century Sidney Spokes (1894) was a great advocate of surgical luxation of teeth which involved moving teeth from a palatal to labial inclination by means of forceps. This was a method which was widely used by himself, by Bryan of Basle, by Dolomore and others, but torsion was considered to be a rather more hazardous method than axial luxation.

Cunningham (1893, 1894) says that "although a certain number of teeth may have been lost by putrefaction of the pulp following upon forcible rotation there is ample evidence that the operation has been successful in a sufficient number of cases to warrant the operator continuing the practice and under such circumstances as the patient being unwilling or unable to undergo the slower but more certain method of rotation by mechanical appliance".

J. F. Colyer in 1900 deals at some length in his notes on irregularities of the teeth with immediate torsion, quoting such disadvantages as liability of the tooth to leave the socket—the risk of death to the palatal vessels from strangulation—fracture of the enamel, and fracture of the root. He suggests that torsion should not be done after the age of 10 but goes on to suggest that it is a reasonable method of treatment in certain circumstances. He then describes 3 cases involving central incisors, 2 of which were rotated through 45° and 1 through 90°; the model of the latter case made 6 years after treatment is illustrated. No further details of these cases were given and no roentgenograms were shown. Neither the patho-histological reactions nor the clinical reactions to vitality tests seem to have been discussed.

Later Tomes discussed again the operation of immediate torsion (Tomes and Newell, 1906). The most favourable age for its performance he thought should be about "9 or 10 years, when the teeth are fully erupted, but when their sockets had not yet attained full strength". This is a significant point to which I shall refer later. Tomes goes on to say that the authors have successfully "twisted central incisors in patients as old as 15 years of age and in several instances in patients aged 13" but he preferred

Given at the Newcastle upon Tyne meeting held on May 11, 1956.

to do it at the younger age. He suggested also that it may be necessary to twist the tooth somewhat farther than is required owing to its tendency to spring back somewhat to its original position. He says that in "several instances thoroughly satisfactory results have been obtained where the tooth needs to be turned through 90° by turning it through only half the required distance, allowing it to get firm again and then after a lapse of a fortnight or three weeks completing the operation by twisting it through the remaining distance. Although on the first occasion the resistance may have been very great the tooth generally yields readily to the second attempt." He considered such a course preferable to the use of great force in order to complete the operation at the first attempt.

We now move on to 1921 when Bocquet-Bull addressed the British Society for the Study of Orthodontics in November and reported upon 8 cases of immediate torsion (1922 a, b). Bocquet-Bull quoted Tomes and Dolomore and Spokes, but said that he was unable to trace any reports of this method being used by anyone else in the country at that time. He considered the dangers associated with immediate torsion to be largely illusory providing cases were selected carefully. After giving an account of his method of turning the tooth, which does not differ substantially from the previous and older described methods, he gave an account of his cases. Now the interesting thing about these cases is that only one is illustrated by roentgenograms and models and it is not clear to which case it refers. It concerns the immediate torsion of an upper central incisor, but 4 cases are reported in all. In the first roentgenogram the apex appears slightly open with the root well formed. After rotation, where the splint may be seen in situ the apex seems almost complete. This is because a different view has now been taken of the tooth; a not uncommon finding. In the third roentgenogram there is a suggestion of an area about the apex; the fourth roentgenogram is a poor one but the tooth seems satisfactory and one can see lamina dura medially. From the first model there would not appear to be room to turn the tooth, but the treated condition in the second illustration shows that this in fact had been done. It is interesting to note, too, in this second illustration that the upper canines are completely blocked out. Bocquet-Bull apologized for the lack of illustrations and records which he blamed upon hospital methods and lack of facilities for storage, care, and supervision of them. It is possible that he showed a few more cases than appeared in the article. The duration over which the cases were reported is not very long. The longest concerned 2 reported after a year—1 reported after 8 months, 1 after $6\frac{1}{2}$ months, 1 after $5\frac{1}{2}$ months, 1 after 5 months, and 2 others which apparently died shortly after operation. A lively discussion seems to have followed the communication of Bocquet-Bull. The President said that he had done some immediate regulations by alveolotomy in the manner of Dolomore and Spokes. He thought that failure in alveolotomy was less than in immediate torsion.

St. J. Steadman thought that the incidence of dead teeth obtained by this method over the past 10 years had been too high. He also said that in his experience the tooth remained permanently tender after the operation. He thought driving of the forceps under the gums very undesirable and he personally would not follow the method. Dowsett criticized the method and thought that part of the periodontal membrane must necessarily be degenerate because its tissues have been severed. He said, very wisely, that he would like to see the records of these cases in 1941 and not in 1921 and he was against the method on the present very limited records of established recorded cases.

Pitts referred to Hopewell-Smith who, he said, used frequently to move teeth by immediate methods. Pitts had done a few cases himself and found them, so far, to be satisfactory. He felt strongly that the blades of the forceps should not go below the gum margin. He usually operated under local anæsthesia. He thought the chances of success were greater with the very young tooth but that the risk of dilaceration was higher, but he thought that might not really matter. He

thought that in order to arrive at a correct conclusion there should be a long series of recorded cases over a considerable period. He himself actually proposed to do some more.

Spokes had done a few cases but was not satisfied with the results and he was inclined to fight shy of the method, though he was whole-heartedly in favour of luxating the teeth over the bite, which he thought on the basis of over a hundred unrecorded cases the simplest and safest of all methods.

Later, in 1933, Bocquet-Bull reported a case of immediate torsion involving secondary orthodontic treatment. Unfortunately original models were lost and not shown. The tooth had been rotated and splinted and the radiograph shows the root only half-formed and the pulp canal widely open at the time of operation. This appears to have been one of the original cases reported to the British Society for the Study of Orthodontics in 1921, but much essential information is missing. In fact, the original date of the operation is not given.

Final roentgenograms show that the apex was normal in the new position and he reported vitality to be fully maintained. Interesting points that he made were:—

1. The reluctance of the tooth under efficient orthodontic treatment to move suggesting that some fibrosis of the periodontal membrane had probably taken place.
2. The development of the root after immediate torsion.
3. The method used in drawing the tooth into a normal position.
4. The vitality of the pulp 4 years after the original operation.

Although Cutler had made vitality tests on this tooth and said that he had used hot gutta-percha and ethyl-chloride with success, finding the vitality to be the same as that of adjoining teeth, Visick pointed out that the pulp chamber seemed to be abnormal and almost obliterated and the President hoped that Bocquet-Bull would be able to report on this tooth in 3 or 4 years time. He said that he himself had a similar case which he had reported and that the follow-up condition was not available at least 10 years after the original operation.

In 1950 A. D. McAlister reported a case of immediate torsion in a girl of 7 who was suffering from a cleft palate and who had been operated upon at 3 months of age. The tooth, 1 month later, was reported to be in good position and reasonably firm in its socket. He comments that rotation of the tooth had corrected a speech defect. In the *Year Book of Dentistry*, commenting on this case the editor says follow-up examinations of vitality of the tooth in this case and in similar cases over a period of years are indicated to establish the merit of this procedure. My own feeling is that it is quite ridiculous to report cases so shortly after operation and that by doing so dentists are exposing themselves to criticism and gaining nothing for the establishment of any method of treatment.

Also in New Zealand in 1950 Professor Pickerill commented on the use of immediate orthodontics (usually by immediate torsion) in cleft palate cases. He thinks that this is a useful and justifiable method but does not quote any particular cases.

And so we come up to the present time. I have thought it important briefly to sketch over the history of immediate torsion in order to put the problem in some sort of perspective. There has been a tendency, of course, for the method to fall out of use and for it to be mentioned less and less in the standard textbooks. The later editions of Widdowson, Colyer, and Sprawson still include it and Colyer and Sprawson give a fairly detailed account of its employment.

Why does the method of immediate torsion carry any attraction? Firstly, and naturally of course, there is the immediacy that is implicit in its description. It is always preferable to get an unsightly and badly rotated tooth corrected quickly and with the minimum of fuss if there are no other drawbacks. The æsthetic improvement is manifest in 3 weeks or less according to how long a splint is kept in position. There is no tendency to a relapse to the former position, and finally there is practically no discomfort from the patient's point of view. If slow or appliance correction were easy to

accomplish there would be no reason to contemplate the surgical method, but rotating single-rooted teeth is not always easy and can all too often be very difficult indeed. The more the rotation the greater the problem and the more slowly must it be accomplished. Once achieved, there is a strong tendency to relapse, which means that the tooth must be

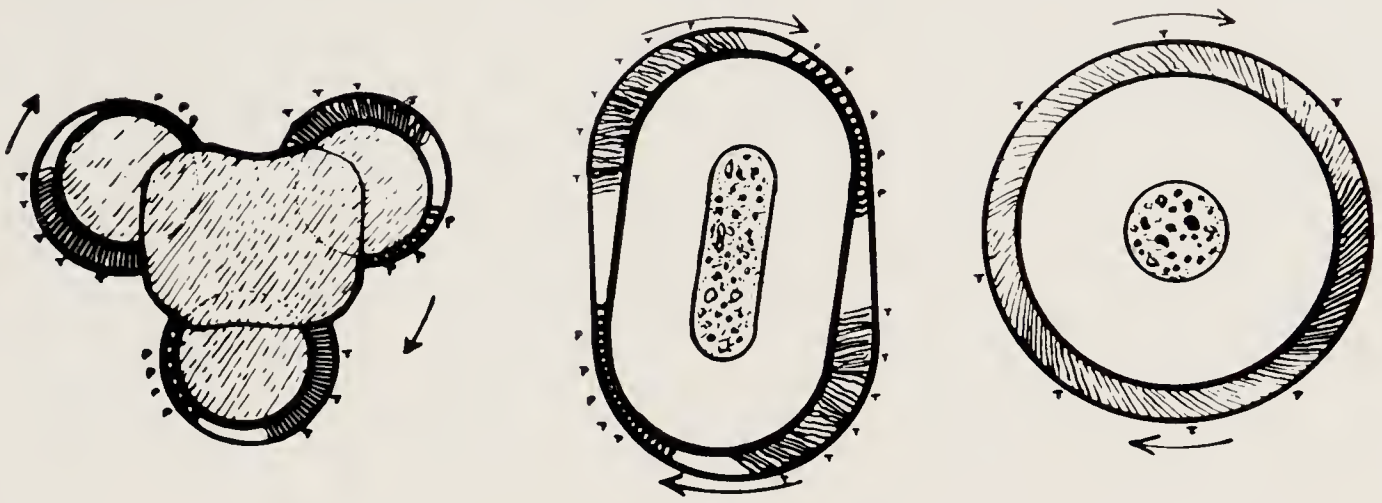


Fig. 1.—Illustrates the difference in the problem of rotating. A, Multirooted tooth, e.g., upper molar. Pressure and tension areas ; B, Elliptical cross-section root, e.g., premolar or canine. Pressure and tension areas ; C, Cross-section of circular root, e.g., maxillary incisor. Tension areas only.

retained for a very considerable time. Removable appliances which look all very well on paper and in theory, are often disappointing in the mouth because of retention and the problem of applying correcting forces precisely to the inclined planes of the tooth crown. Rotation of multirooted teeth is much more simple but the problem is essentially a different one. Here the roots are moved bodily within the bone and even oval shaped roots are easier because definite areas of pressure and tension are developed (*Fig.* 1 A, B). But in torsion of single near-conical roots, areas of pressure are not well developed. The whole periodontal membrane is put into a state of similar strain (*Fig.* 1 C) which causes reaction, inflammation, and, if the forces are severe, supra-occlusion of the tooth because of general inflammatory changes. Why the tooth should so persistently tend to relapse is not yet clear, but it may be that the socket is not completely remoulded to the tooth in its new position as occurs in axial movements in teeth. It would take some prolonged animal experiments to settle this point, but it is not easy to find an animal with suitable teeth—that is to say with straight conical roots and adequate crowns for the supporting of bands and cleats. Monkey incisors for example have a very pronounced curve in their roots.

Now immediate torsion is probably a matter of autogenous replantation with the tooth never leaving the socket. This is, of course, a slightly paradoxical way of putting the matter but it is, I think, accurate. I very much doubt whether there is any actual twisting of the afferent or efferent vessels; they probably all rupture along the lenticular boundary of the epithelial diaphragm (*Fig.* 2 a, b) and then rapid healing with revascularization ensues.

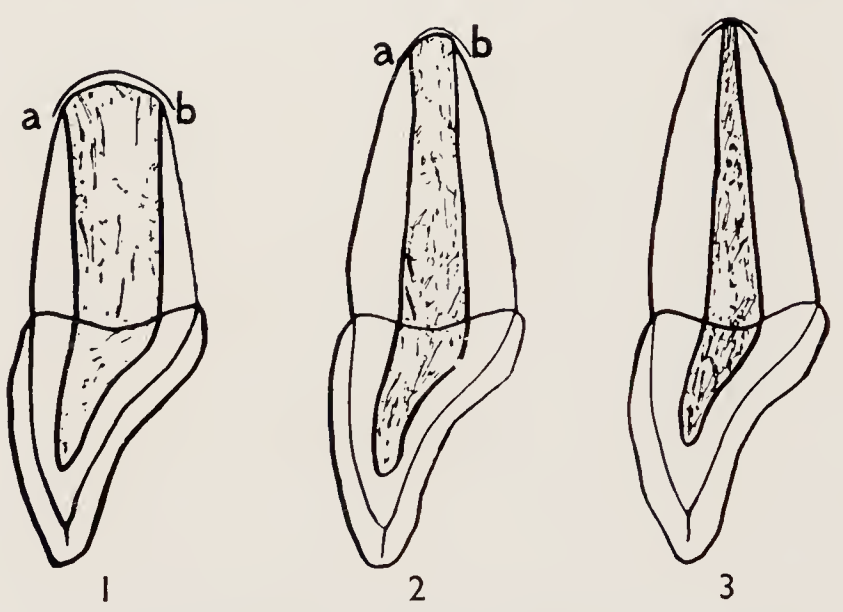


Fig. 2.—Showing a–b, varying width of lenticular boundary of epithelial diaphragm.

There is a minimum of sepsis because the tooth never leaves the socket and therefore healing conditions are at an optimum. We all know that extracted teeth, if replaced, can in a small number of cases give long service to their owners. Mostly they show either slow or galloping resorption, but in a few it becomes

almost impossible to detect that the tooth was ever parted from its socket. The reacceptance by the body of its own tissues either reimplanted or transplanted is always a matter of great surgical interest, as is the acceptance of grafts and implants of heterogenous origin, and the plastic and ophthalmic surgeon continue to persuade the body to accept a variety of materials in place of the natural tissues such as orlon, nylon, acrylic, tantalum, stainless steel. The turning of a tooth within its own socket is surely worth serious investigation.

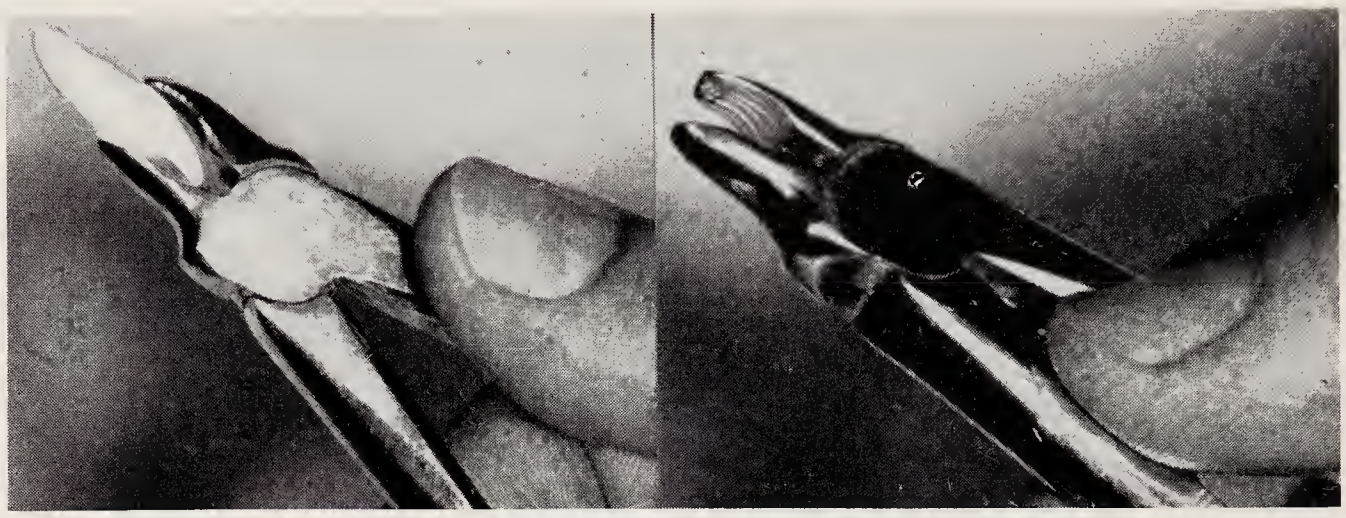


Fig. 3.—Forceps with beaks specially adapted to grip central and lateral maxillary incisors during immediate torsion.

The method of torsion is described briefly:—

Under local or general anæsthesia the crown of the tooth is seized by special forceps designed to prevent the tooth leaving its socket (*Fig.* 3) and, with a steady and mounting force, a rotatory movement is applied. The tooth may be stubborn or easy. Personally I am happier about those that turn easily, but I know no way of determining this reaction beforehand. When the tooth is loosened—that is to say when all the fibres of the periodontal membrane rupture—it will turn very easily. It must not be pressed too firmly in an apical direction. In its new position (which may not be wholly satisfactory labiolingually) it should be steadied and then splinted. There is slight gingival hæmorrhage and I like to keep a generous application of "Pencigel" to the cervical margin. The splint is only partly prefabricated by constructing orthodontic bands on one or more of the adjacent teeth and also to the turned tooth before operation. To the stabilizing teeth is welded a piece of 1 mm. stainless steel wire. Immediately after the torsion in the case of a local anæsthetic, or half to three-quarters of an hour afterwards in the case of a general anæsthetic, the bands are then reapplied and the bar adjusted with pliers until it lies passively upon the band on the turned tooth. A light weld is then made and the splint tried again. If correct a full weld is made and a little solder may be added. The splint is then cemented, left in place for two or three weeks, and then removed. There has not so far been in any case of mine any post-operative discomfort. I prefer to make my splints in this way rather than preform them on the model as these can never be correct, for one is never quite sure exactly how the tooth will move. The prefabricated splint, unless one is very fortunate, is likely to hold the tooth in a position of strain in relation to its socket whilst the one made up after the torsion will not do so. On occasion the tooth has seemed to be so firm immediately after torsion that I have left it thus, unsplinted, merely asking the patient to be careful, and there has been no untoward result (*Case* 8, *Fig.* 7).

A minimum of five years, in my opinion, must elapse before one can determine reliably the reactions of the tooth and investing tissues. During the turning, if the tooth has been stiff and obstinate, small fragments of cementum may become detached. This would leave bare dentine and a focus for resorption may be created. If the tooth yields easily this is less likely to happen. During a difficult turning extra force is needed. When applying the forceps only turning force should be applied as any intra-alveolar intrusion of an immature tooth into its socket should be avoided. Such force could easily cause compression of the

very delicate pulpal tissue against the base of its socket, which could produce in turn intra-pulpal hæmorrhages which might lead to greater degenerative changes than otherwise. This is a point which I did not appreciate in my earlier cases. Also the pressure of the beaks of the forceps on the tooth crown momentarily distorts the underlying flexible dentine. This, if too severe, can result in sharp odontoblastic reactions which may be resolved as a thick layer of secondary dentine. Compression of the crown by the forceps may also fracture the enamel. By interposing lead foil between the blades this is less likely to happen.

Because, personally, I like to turn a tooth in a firm socket and at the same time have as open an apex as possible, I usually choose a stage of development where the root is at least three-quarters completed. This seems to me to be the optimum stage of development. If turned too soon, say in the stage of development shown in *Fig.* 2 1, not only may pulpal compression be easily caused but a large area of Hertwig's sheath will be torn and deformed. At the stage shown in *Fig.* 2 2 the sheath is contracted to a smaller "tube" which may be more resistant to rupture, though a slight twisted dilaceration must be inevitable. At the stage in *Fig.* 2 3 rupture or strangulation of the pulpal vessels can hardly be avoided and the risk of poor or non-revascularization is very high, particularly with second incisors which often have an apical bend in the root. Some time after the torsion small roughnesses may be noted on the sides of the root when viewed radiographically. These are resorption areas. They may progress very slowly, or they may fill with cementoid and the Sharpey's fibres become reattached and a *status quo* arise. Naturally if the resorptions are labially or palatally placed they will be very difficult or

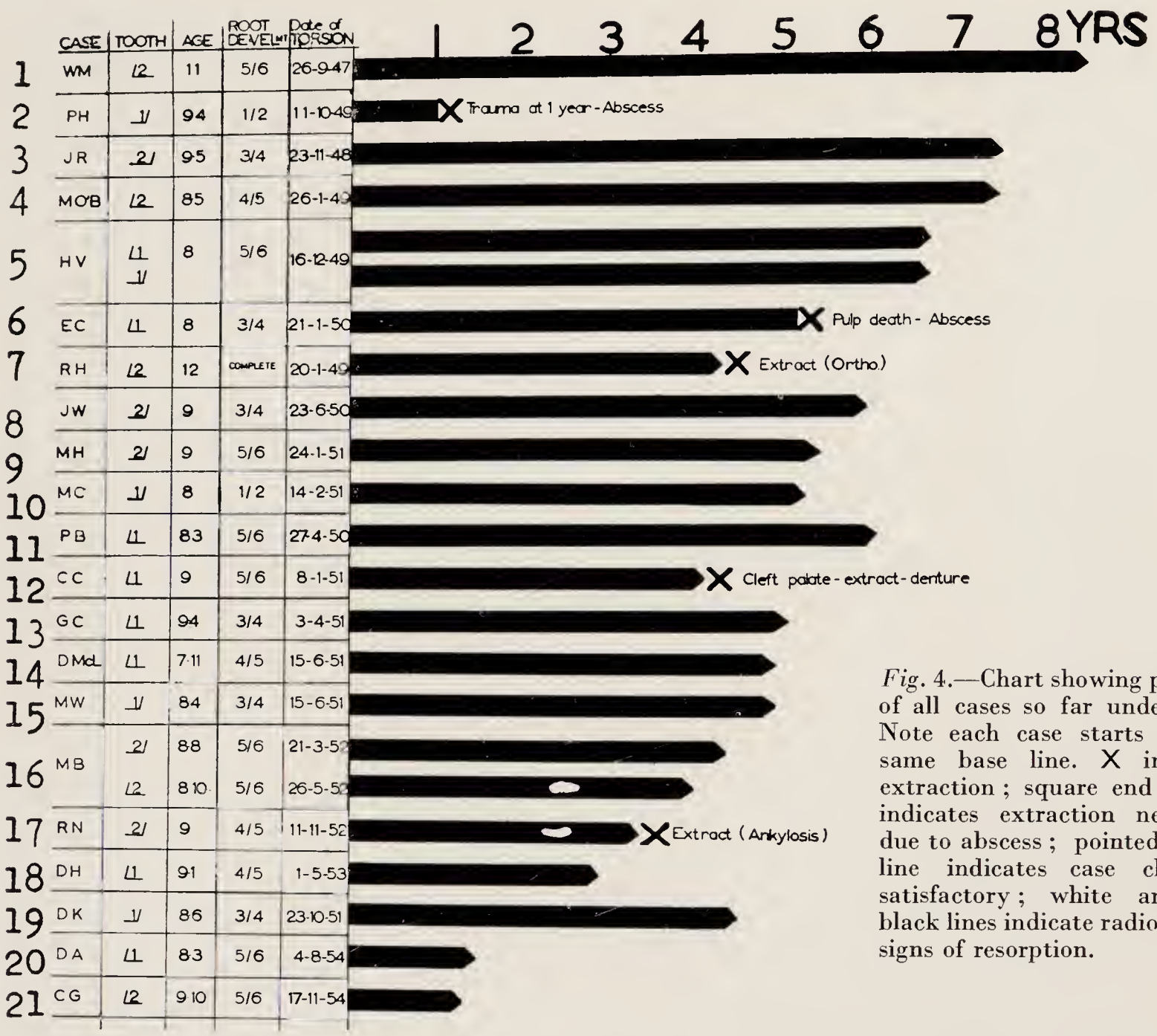


Fig. 4.—Chart showing progress of all cases so far undertaken. Note each case starts on the same base line. X indicates extraction ; square end to line indicates extraction necessary due to abscess ; pointed end to line indicates case clinically satisfactory ; white areas in black lines indicate radiographic signs of resorption.

impossible to interpret from the roentgenogram in the early stages, though they may become quite apparent later on as they become more advanced (*Case* 17, *Fig.* 8). The resorption may become extensive, but nevertheless the tooth remains firm over many years and quite symptomless. The apex may be watched completing. This is, of course, encouraging and it does usually occur, and may do so despite the fact that the pulp is undergoing slow degeneration. It may also continue to respond in a lively fashion to thermal tests though much calcification has taken place within the pulp chamber. This is in accordance with the observations made previously by Bocquet-Bull on the case of immediate torsion which had been tested by Cutler and commented upon by Visick (*vide supra*). This is one of the interesting observations found not only in these teeth but also sometimes in replanted teeth and in pulpotomized teeth. The pulp may eventually wholly calcify, being filled with a form of pulp bone.

What is the general assessment of these cases on the basis of this interim report?—and here I must make it clear that my ultimate aim is to follow at least 20 of these cases for 8 years, and if possible I hope to follow 25 cases. Originally I had hoped to follow them for 10 years. This may yet be possible, but so long as National Service exists and takes our young men in at 18 it becomes very difficult to pursue serial cases in boys much beyond 17. So that as most of these teeth are turned at age 9, only 8 years are available.

Firstly it may be seen from many of these cases that they react in very variable ways. With the same technique of turning and stabilization some show resorptive changes to a considerable degree and others practically none. In some, the resorption has not become apparent until three or four years after turning. Degenerative changes in the pulp leading to necrosis definitely followed in one case (*Case* 6) though it took four years to do so. A second failed, having had a severe blow a year after turning (*Case* 2). Vitality is maintained in the great majority, even in those where resorptive changes may be advanced. One of the definite disadvantages is that, if resorption takes place, repair may be followed by ankylosis. The tooth seems then to remain at its original level in relation to the cranial base, being left behind by the descent of the occlusal plane (*Cases* 16, 17, *Fig.* 8). Since children vary enormously in the amount of descent of the occlusal plane during facial development, submergence will be much more pronounced in those children who develop great facial depth than in those who do not. It is an argument for turning at the last possible moment compatible with an open apex. Occasionally the enamel is chipped. This occurs because some teeth are much more resistant to turning than others and greater force is necessary. I have one patient in whom the right lateral incisor turned quite easily. This latter easily-turning one produced an excellent result—whilst the difficult tooth gave a poor one (*Case* 16). The possible relationship between the detachment of cementum and subsequent resorption in these difficult cases has been mentioned.

The gingival condition has remained uniformly good and in no case has any deep or significant pocketing resulted. The periodontists should be interested in this finding. At the termination of the eight-year period of a sufficient number of cases I hope to measure comparatively all the gingival crevices.

It will be seen that in almost all my cases I have chosen those teeth which were a very serious problem from the rotational point of view. Originally, and in error (as I now know), I also made a stipulation, as it were to myself, that I would only turn teeth where a canine was blocked out. So that, if after six months to a year, should the turned tooth prove satisfactory I could then extract the first upper premolar and let the canine come into place. If it should not be satisfactory then I could extract the turned tooth and let the canine come into the lateral space. In a word, I tried to ensure that I had a second line of defence. I now know that this is not sound reasoning for it takes much longer than one year to be sure of a good result and indeed it is better to wait for three. So that, long before that time has elapsed, something quite definite may have to be done about the blocked out canine!

CASE REPORTS

Case 1.—W. M. (male). $\underline{|2}$ rotated 110°. Turned age 11 years. Root nearly complete. Splinted. Has been satisfactory for $8\frac{1}{2}$ years. Vitality and thermal tests normal. Has had small distal filling placed 5 years ago. Pulp chamber slightly reduced in comparison with $\underline{2|}$. Some roughening of root distally. Slight resorption of cementum distally just below gum margin. Pulp shows slight areas of calcification. Colour excellent. Gum margin normal. Tooth quite firm. Occlusal level satisfactory.

Case 2.—P. H. (male). $\underline{1|}$ rotated 90° due to supernumerary. Large teeth. Rotated at age 9 years 4 months. Root half formed. Satisfactory 11 months after but patient suffered severe blow followed by acute abscess. Tooth had to be extracted 1 year after torsion.

Case 3.—J. R. (male). $\underline{2|}$ rotated 90°. Age 9 years 5 months, root three-quarters completed. Tooth turned, splinted. Satisfactory $7\frac{1}{2}$ years. Vitality responses normal. Suggestion of slight resorption distally. Apex a little blunted. Lamina dura continuous medially. Slightly discontinuous distally. Occlusal level satisfactory. Distal filling.

Case 4.—M. O'B. (female). $\underline{2|}$ rotated 80°. Age 9 years 5 months, root three-quarters developed. Tooth turned, splinted. Seven and a half years satisfactory. Normal response to vitality tests. Lamina dura intact. Pulp size normal. No histopathological change detectable. Occlusal level normal. (*Fig.* 5.) (Tooth turned by Mr. W. H. Littlefield.)

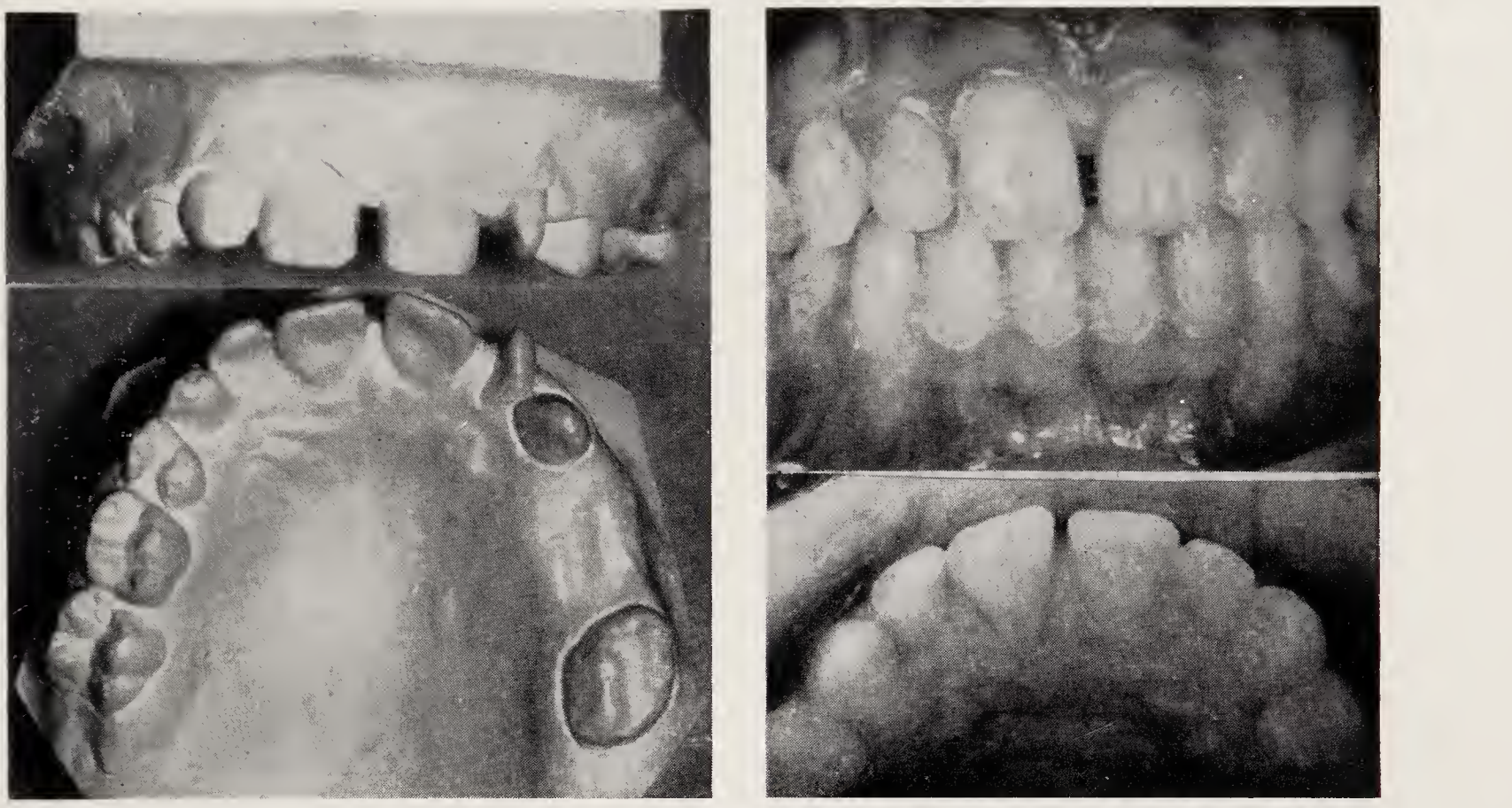


Fig. 5.—*Case* 4 (*see Fig.* 4). A, $\underline{|2}$ before torsion; B, $\underline{|2}$ seven years later; C, $\underline{321|123}$ before torsion; D, $\underline{|2}$ splinted after torsion; E, Seven years later, aged 15 years 6 months.

Case 5.—H. V. (male). $\underline{1|1}$ rotated 70° due to presence of supplemental $\underline{2|2}$. Age 8 $\underline{1|1}$ rotated and splinted and right upper supplemental incisor extracted. Later, left upper supplemental extracted. Great improvement in appearance. Patient lost sight of for 3 years due to back injury. Seen again $6\frac{1}{2}$ years after torsion. Teeth satisfactory. Reaction to thermal tests normal. Gum

condition excellent. Occlusal level normal. Pulp condition—evidence of slight calcific change on roentgenograms. Apices complete. Left upper canine ectopic. Small brown hypoplastic pateh on $\underline{1}|$ near gingival margin. Possible slight resorption distal surface of root $\underline{1}|$ and medial $|\underline{1}$. (*Fig.* 6.)

Case 6.—E. C., female. 90° rotation $|\underline{1}$ due to mesiodens. Age 8, three-quarters root development. Tooth rotated and splinted. Position after rotation only fair due to angulation of socket. Three years later evidence of considerable resorption radiographically. Five years later tooth developed acute abscess and was extracted. This case must be regarded as a frank failure.

Case 7.—R. H., male. $|\underline{2}$ rotated 90°. Age 12, root complete. Immediate torsion and Class III palatal invagination was also present. After torsion tooth was found to be inclined too far labially. After 6 months orthodontic pressures were applied to move tooth in a palatal direction. Four different appliances were tried but the tooth would not move. This tooth had been very resistant to turning. It was finally removed after 4 years and a bridge was inserted. The tooth was extracted quite easily and there was no ankylosis. Sectioned for histological examination. At time of removal was symptomless and gum condition excellent. Occlusal level also satisfactory.

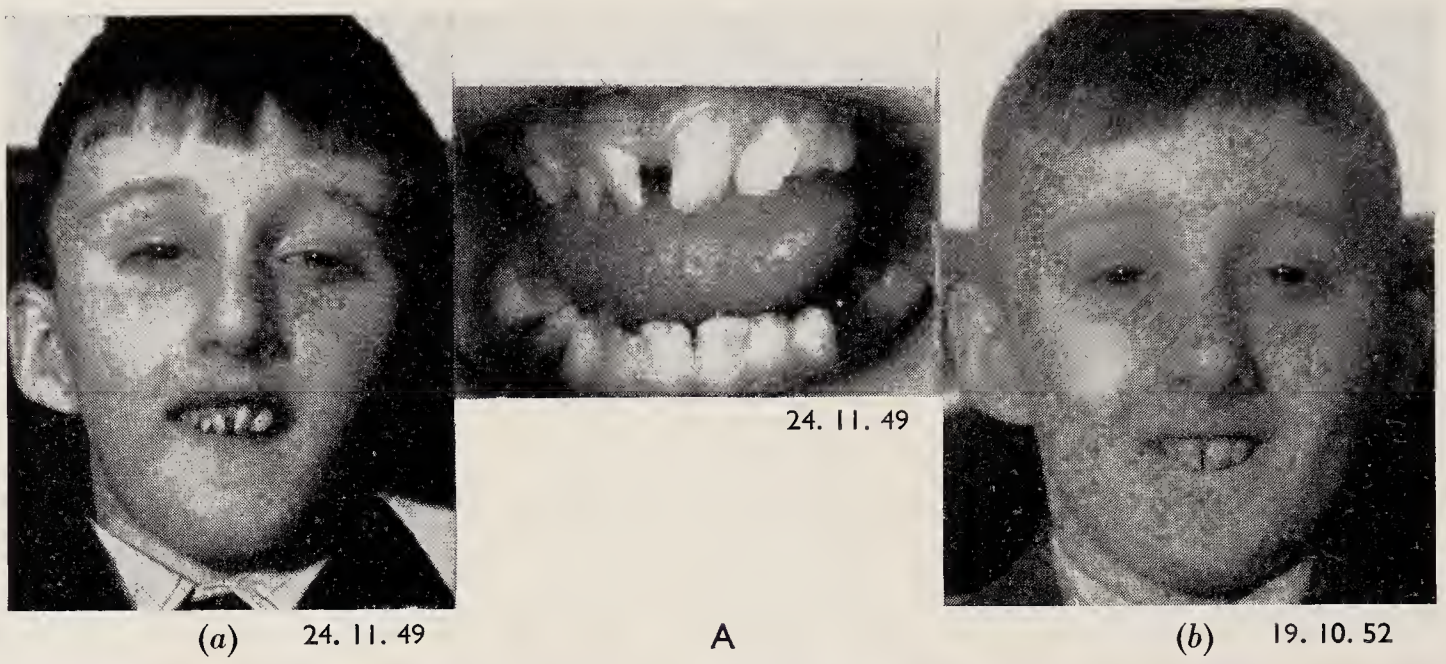
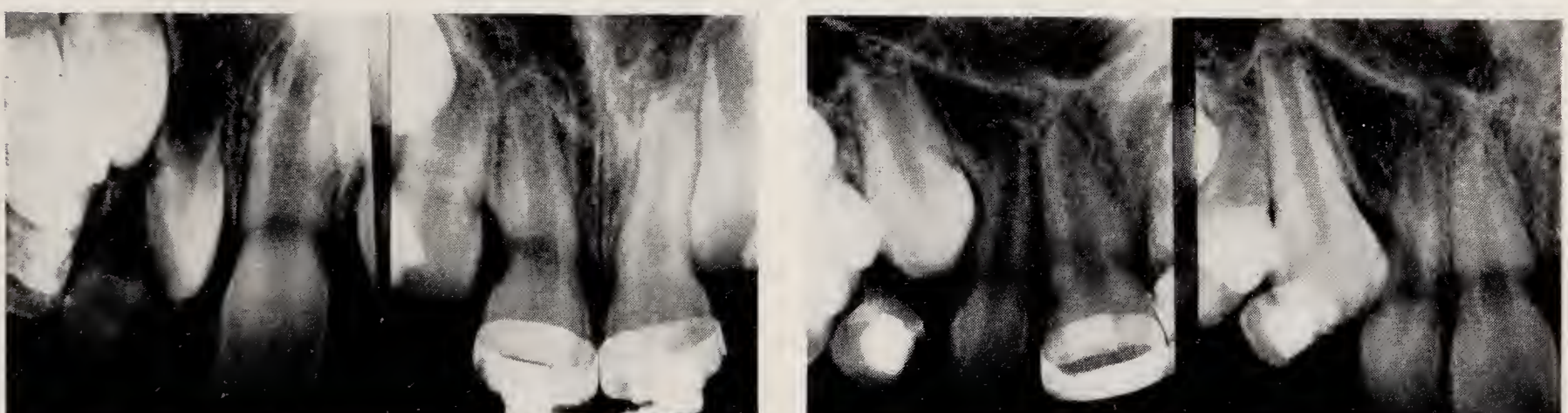


Fig. 6.—*Case* 5 (*see Fig.* 4). A, (*a*) Before torsion; (*b*) Two years after torsion. B, $\underline{1|1}$ after six years (supplemental $\underline{2|2}$ have been removed). C, Radiograph before torsion. D, After splinting. E, Six years later.

Case 8.—J. W., female. $\underline{2}|$ rotated 45°. Age 9, root three-quarters complete. Tooth corrected by immediate torsion. After turning seemed so firm with complete absence of bleeding that no splinting was applied. Healing uneventful. Nearly 3 years later tooth colour Slight evidence of roughening of root distally but compares well with unturned $|\underline{2}$ both in pattern of periodontal space and pulp size. Has had small filling inserted medially. Reacts well to thermal tests. Occlusal level normal. Case very satisfactory.

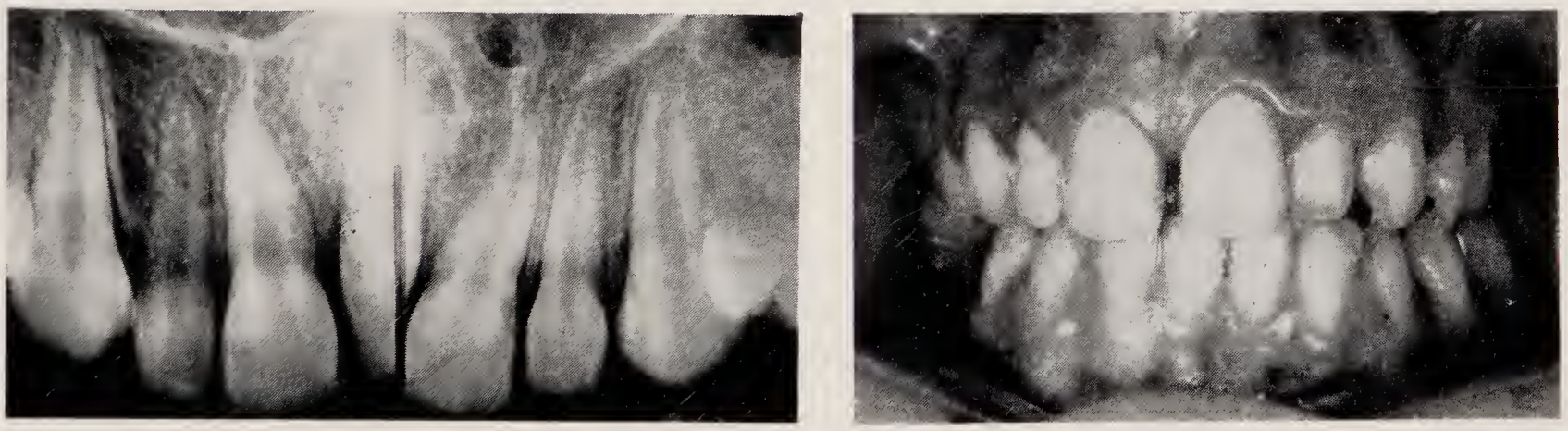
13. 11. 48 (*a*) Age 7.5 — 27. 6. 50 Age 8.9 — (*b*) Age 15

A



13. 11 48 (*a*) — (*b*) 26. 3. 49 — 27. 6. 50 — 4. 5. 51

B C



15. 4. 56 — 15. 4. 56

D

Fig. 7.—*Case* 8 (*see Fig.* 4). A, $\underline{2}|$ before torsion: (*a*) Before closure of diastema $\underline{1}|\underline{1}$; (*b*) Six years later, aged 15. B, (*a*) $\underline{2}|$ erupting in rotated position; (*b*) Diastema has been closed and has been held. C, Left tooth turned but firm and not splinted. D, April, 1956, six years later.

and occlusal level normal. Responsiveness to vitality tests normal. Apex has completed. Some slight evidence of resorption. Six years later tooth still clinically very satisfactory. Radiographically, evidence of some slight resorption though this is not severe. Occlusal level and gum condition still excellent. (*Fig.* 7.)

Case 9.—M. H., female. $\underline{2}|$ rotated 90°. Root three-quarters complete. Splinted. Satisfactory $5\frac{1}{2}$ years.

Case 10.—M. C., male. $\underline{1}|$ rotated 80°. Cleft palate case, right side. Absent $\underline{2}|$. Tooth turned age 8. Root half complete. Has been satisfactory over 5 years. Great improvement in position though tooth still remains (together with $|\underline{1}$) lingual to $\overline{1|1}$. Root has completed its apical development and no evidence of any marked resorption so far. Occlusal level is satisfactory. This tooth may be removed later for histological investigation when a prosthesis is fitted.

Case 11.—P. B., female. $\underline{|1}$ rotated 70°. Cleft palate case, left side. Tooth turned and splinted—root five-sixths complete. Premaxillary teeth lingual to lower incisors. Great improvement in appearance especially after medial corner of turned tooth had been stoned. Has been satisfactory over 6 years. Responds well to thermal tests. Periodontal condition satisfactory. No evidence of resorption.

Case 12.—C. C., female. $\underline{|1}$ rotated 45°. Cleft palate case left side. $\underline{2|}$ malformed and extracted. Tooth turned age 9. Root five-sixths complete. Satisfactory 4 years with slight indication of calcification in pulp chamber. Distal filling placed in crown. Periodontal condition normal with no evidence of resorption. Tooth extracted after 4 years in preparation for prosthesis. It was hoped to have this tooth for histological examination but due to an accident of understanding the tooth was thrown away by practitioner after extraction. This tooth had reacted normally to vitality and can be considered as a satisfactory case.

Case 13.—G. C., male. $\underline{|1}$ rotated 45°. Cleft palate case, left side. $\underline{|2}$ absent. Tooth turned and splinted age 9.4. Root three-quarters complete. This tooth was somewhat hypoplastic in appearance. Apical development only partially complete after torsion and tooth did not react well to thermal tests. After 2 years pulp canal was opened and the pulp found to be dry and degenerate. Root filled. After 5 years tooth extracted for denture. Tooth at the time firm, gingival condition good and occlusal level satisfactory.

Case 14.—D. McC., male. $\underline{|1}$ rotated 75°. Cleft palate case, left side. Malformed lateral incisor present which was extracted. $\underline{|2}$ malformed which was extracted. Tooth turned and splinted age 7 years 11 months. Root four-fifths complete. Apex has since completed development and tooth has been in place for 5 years. Occlusal level good. Thermal reactions normal. Periodontal membrane normal. No evidence of resorption. Edge to edge bite. This case seems to be quite satisfactory.

Case 15.—M. W., female. $\underline{1|}$ rotated 150°. Tooth turned and splinted—age 8 years 4 months. Root three-quarters complete. Condition after turning very much improved but not 100 per cent satisfactory. Apex has completed with some dilacerations. Root canal lumen has narrowed. Tooth reacts well to thermal tests. Slight evidence of medial resorption. Gum condition good. Occlusal level satisfactory. A very severe case of rotation which would have been extremely difficult to treat by any other way. Has been satisfactory for 5 years and may be considered as a successful case.

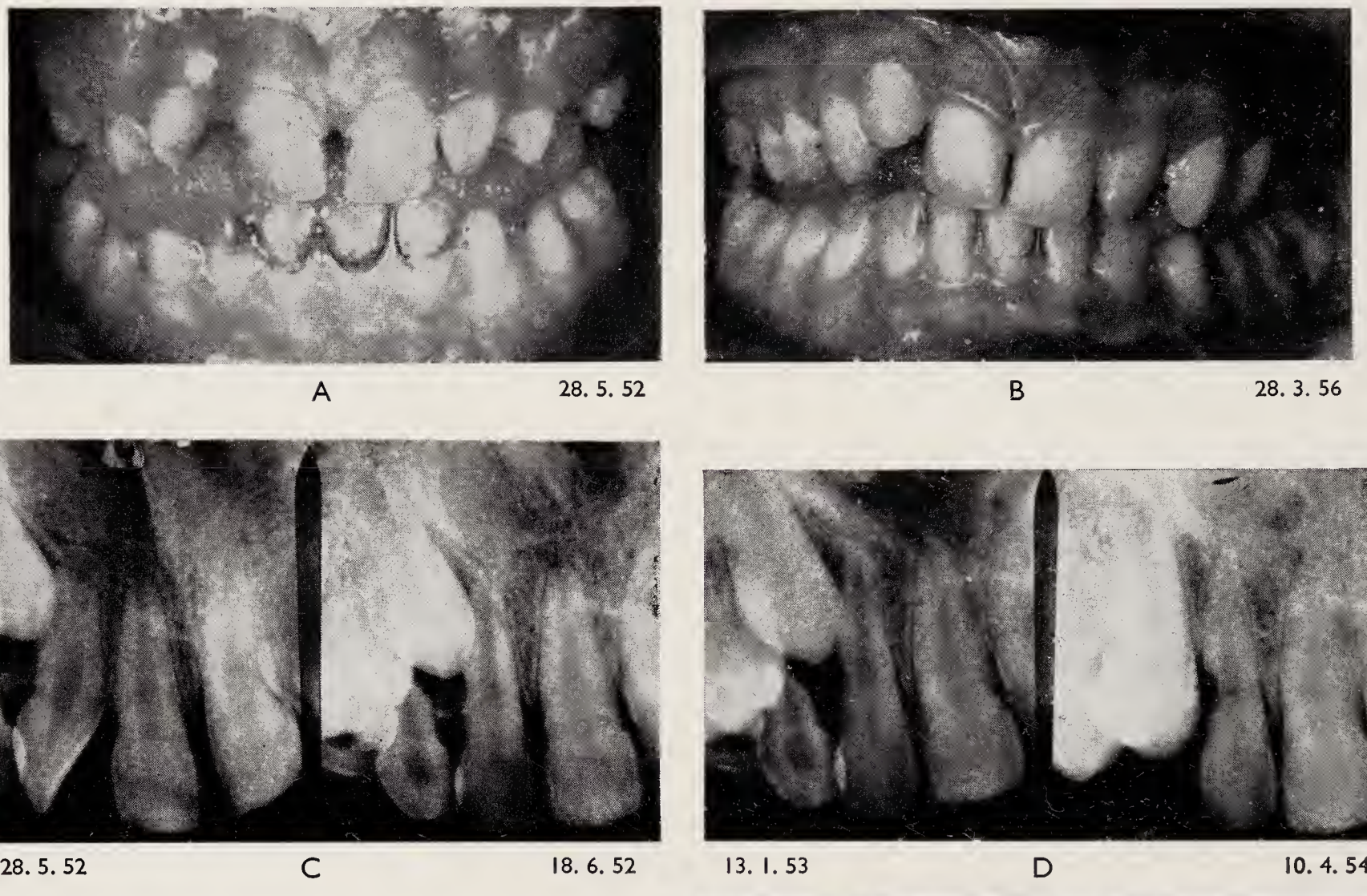


Fig. 8.—*Case* 17 (*see Fig.* 4). A, $\underline{2|}$ before torsion. B, Three and a half years later; at time of torsion incisal edge was at occlusal level.

Case 16.—M. B., female. $\underline{2|2}$ rotated 90°. $\underline{2|}$ turned age 8 years 8 months. Root five-sixths complete. Splinted. $\underline{|2}$ turned age 10, five-sixths complete, splinted. $\underline{2|}$ turned quite easily. $\underline{|2}$ very resistant and small chip fractured off enamel incisively during turning. $\underline{2|}$ has been quite uneventful, reacts well to thermal tests and shows small area of resorption distally and just below cervical margin which has not progressed markedly for 3 years. Occlusal level and gingival condition satisfactory. $\underline{|2}$ has completed root development but began to show root resorption one year after turning. This has progressed extensively though the surrounding bone has remained radiographically normal. This tooth has remained at its original level of development and is in a condition of infra-occlusion. Patient was advised to have tooth extracted but preferred not to do so. The crown was therefore lengthened artificially with a three-quarter crown and acrylic facing. It therefore appears abnormally long. This tooth continues to react in a very lively way to thermal tests. Gum margin good. This case is interesting in view of the dissimilar results following similar technique in the same patient.

Case 17.—R. N., male. $\underline{2|}$ rotated 90°. Turned age 9, root four-fifths complete. Splinted. Tooth resistant to turning. Root development completed. About 1 year later began to show area of resorption distally which spread fairly extensively although apical half of root remained quite normal. Tooth quite symptomless but remained at original occlusal level and developed marked infra-occlusion. For this reason extraction was advised $3\frac{1}{2}$ years after turning. At time of extraction tooth felt "ankylosed" and crown parted readily from remainder of root. The coronal portion of the pulp on macroscopical investigation looked normal but root portion may need surgical removal. As it is symptomless and there is no sepsis present the root is being left in situ for the time being. This case must be regarded as a frank failure. (*Fig.* 8.)

Case 18.—D. H., male. $\underline{|1}$ rotated 90° due to supernumerary. Tooth rotated age 9 years 1 month when four-fifths completed. Tooth stabilized. Has remained symptomless, reacts to thermal tests normally, gum condition excellent but after 3 years tooth is now beginning to show signs of infra-occlusion. It is anticipated that the infra-occlusion will become more marked in the course of the next 2 years. The full success of this case must be regarded as doubtful.

Case 19.—D. K., male. $\underline{1|}$ rotated 45°. Cleft palate case, right side. Supplemental $\underline{2|}$ present and rotated also. Supplemental $\underline{2|}$ extracted. $\underline{1|}$ turned age 8 years 6 months, root three-quarters complete. Splinted. Position after rotation only fair. Four and a half years later position of tooth only fair because of angulation. Some possible calcification of pulp canal. Apical development complete. Tooth reacts well to thermal tests. No resorption apparent but difficult to assess because shadow of root overlies that of adjacent central incisor. Extraction advised but patient prefers to retain tooth for time being. It is hoped that this tooth will become available for histological section at some later date. Case moderately satisfactory.

Case 20.—D. A., female. $\underline{|1}$ rotated 80°. Tooth turned age 8 years 3 months, five-sixths complete. Splinted. Has now been rotated $1\frac{1}{2}$ years. Condition satisfactory. Root apex has been completed. Periodontal membrane seems normal radiographically. Occlusal level normal. Responses to thermal tests normal. Gingival condition good. No signs at present of focus of resorption. This case must not be considered as satisfactory until at least another $2\frac{1}{2}$ years have elapsed.

Case 21.—C. G., female. $\underline{2|}$ rotated 90°. Tooth somewhat diminutive. Tooth rotated five-sixths complete. One and a half years later tooth normal in appearance and reactions to thermal tests. Lamina dura satisfactory. Case so far satisfactory but no further judgement can be made upon this until another $2\frac{1}{2}$ years have elapsed. *Vide* remarks on previous case.

GENERAL CONCLUSIONS

In this limited number of cases it would be unwise to be too dogmatic on the outcome in general of immediate torsion. This paper must in no sense be construed as an effort on my part to popularize this very old method of treating cases of rotation. It is claimed, however, that, as far as I am aware, more cases of immediate torsion have been followed through for a longer period than has been done previously and a considerable amount of clinical and radiographic material is now at my disposal. Ultimately there will also be some human histological material. Similar torsion experiments have also been carried out on monkeys, but the results of this work is outside the scope of this paper as I thought in the limited time available it would be better to confine myself to the concrete facts and known human clinical histories.

Immediate torsion is interesting not only for itself alone but also for the indications it gives us as to the reactions of investing tissues of the tooth after accidental trauma, subluxation, and so on. Briefly then, it can be said that immediate torsion on single rooted teeth can be demonstrably successful and teeth so turned are now serving perfectly well with good vitality without sepsis, change of colour, or paradontal break down more than seven years after treatment. In most cases some resorption of the root takes place which is usually followed by repair tissue and eventually a *status quo* is established. In a few cases the resorption proceeds at a greater pace than repair and the root largely disappears. As a result of ankylosis the tooth may become fused with the investing alveolar bone and fail to continue eruption along with the

adjacent teeth. A marked disparity of occlusal level then becomes apparent which is æsthetically displeasing. Very occasionally the tooth may die and abscess formation supervene. The enamel may be chipped in certain cases of stubborn teeth. The gingival condition seems to remain uniformly excellent. It is suggested that in cases of gross rotation, cleft palate and others with supernumerary involvement immediate torsion may justifiably be employed. Also in some cases where the patient may have to travel long distances and regular attendance is difficult or impossible this method may be used to correct badly rotated teeth providing that the position is clearly explained to the parent.

Acknowledgements.—Thanks are due to the Department of Photography of the Newcastle upon Tyne Dental Hospital, for the production of the photographs illustrating this paper.

At the time of going to press a further six months have elapsed since the delivery of this report. It is of interest, therefore, that the position has remained exactly as in May. There has been no further changes of any significance in that time.

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DISCUSSION

The Chairman said just recently there had been a resurgence of interest in the surgical treatment of local malocclusions of teeth, but by autografts and homografts, and as Professor Hallett had said this was really a form of autograft rather than a simple rotation. It had indeed been a most interesting and timely paper.

Mr. Watkin said he had never rotated a tooth surgically but one point had struck him in the case which Professor Hallett had pointed out of a tooth which did not erupt; he was not quite sure whether that was not caused by the presence of the tongue, which seemed to be quite big and was protruding.

Mr. Breakspear said it would appear that the teeth which were difficult to turn, presumably because of the shape of the bony socket, were just the very ones which might be expected to give a better result by the more orthodox methods. It would be interesting to know whether Professor Hallett agreed with that, and if so whether there was any way of telling beforehand which teeth would respond better.

Mr. Pilbeam said he was particularly interested in the history of the cases as given by Professor Hallett in regard to Bocquet-Bull's paper read before the Society in 1921.

He had seen Bocquet-Bull do a number of immediate torsions, in which he always used unvulcanized rubber instead of lead foil to protect the tooth and always used a pre-arranged splint because it gave greater support. After some little time Bocquet-Bull did tell him that he had given up the practice because the results were so disappointing.

Mr. Hamish Anderson congratulated Professor Hallett on his excellent paper but wondered whether he had taken into consideration the aetiology of the displaced teeth. Might some of them not be due to the deciduous teeth? Secondly, as the tooth was erupting it might be an occlusal contact, in other words a slight rotation, and perhaps that might have some influence on the results.

Mr. Logan said the question of the rotation of teeth was an extremely interesting one and he had listened with great pleasure and profit to Professor Hallett's very extensive review of the subject. He did not agree, however, that the rotation of a tooth in its socket could be regarded as a homograft: in his opinion the true homograft was where one extracted a tooth and made a new socket for it and replanted it. It was an extraordinary thing that if one did that, every case in the end failed. His own experience was that a tooth replanted in a new socket lasted about four years when, the root having been absorbed, the crown fell. If, however, one rotated a tooth in its socket the root sometimes showed greater or less loss of substance by absorption, sometimes not. It would appear that the critical point lay in the presence of the periodontal membrane and it was interesting to speculate why it was that the root was not always absorbed. His own view was that it was probably due to the epithelial elements in the periodontal membrane. If they were destroyed root resorption would occur.

It would appear that the epithelial attachment was fractured and re-attached itself in some way and it was very interesting indeed to see cases which had lasted for such a long time, and even cases where ankylosis was taking place.

His own experience was that the dangerous period occurred after the fourth year and he believed that there is a spate of absorptions after this time.

Mr. Kettle said that in his opinion the rotation of incisors was a local manifestation of a general orthodontic problem and that it was of no value to attempt treatment of that local symptom until the orthodontic

problem as a whole was treated. When that was done the rotated incisors would almost invariably look after themselves in the course of the orthodontic treatment. If the results which Professor Hallett demonstrated had shown the loss of one tooth then in his view the method should be condemned.

Mr. Walpole Day said in order to get the thing into perspective it should be realized that all the cases which Professor Hallett had shown were cases where heroic methods were necessary to correct them, and it would be interesting to know whether Professor Hallett or anyone else had a comparative series of cases which had been treated by other methods, with the appropriate X-rays, showing how many of those cases also had failed. Of the series of cases shown by Professor Hallett four had failed—how many had failed by other methods such as twin arch or similar fixed apparatus?

Mr. Wilson said in the cases shown he did not think there were any central incisors with root resorption—they were all laterals—and he wondered whether there was any significance in that.

Professor G. E. M. Hallett, in reply to Mr. Watkins, said he did not think so in that particular case. There were in fact two cases where that had happened; these had involved teeth which had been hard to turn and he had anticipated little trouble at the time of turning but it was only later that the disparity in occlusal level had developed. He felt sure it was due to an ankylosis similar to the ankylosis seen in submerged deciduous teeth.

In reply to Mr. Breakspear he said he was unfortunately unable to help in that respect. He had already cited a case where a tooth had been splinted on one side. In that case both teeth were rotated through a similar number of degrees and the one on the right had moved into an excellent position with no orthodontic help at all, which in fact had rather surprised him, whereas the other one, which had been difficult to turn, was the one on which he had to put the rather peculiar-looking elongation (of which he was not particularly proud). However, the patient insisted upon keeping it. He only wished he could determine that particular point.

In reply to Mr. Pilbeam with regard to splinting, Professor Hallett said he had done about three cases which he had not splinted and they had been satisfactory and this had left him wondering whether with ankylosis tending to develop round little detachments of cementum it might be that a slight movement would be advantageous whereas if the tooth were too rigidly splinted, after a resorption cavity had been formed redeposition of osteoid with consequent fusion would be facilitated. That was a thought which had occurred to him quite recently as a result of his experience and also of one or two of his animal experiments.

Replying to Mr. Anderson, he said in the case to which Mr. Anderson referred there had been two supernumeraries in the palate which had had to be removed first and indeed in some of his cases supernumeraries had been important factors in causing incisor rotations. In addition, in that particular case the patient had very large teeth, and that might also have been a factor which was against him, for although he had actually regained space there, hoping to extract further back, he had probably not expanded quite enough before turning the tooth. The patient was a very active boy.

In reply to Mr. Logan, Professor G. E. M. Hallett said he had done other forms of surgical correction of teeth. He remembered a Class III case where a young boy had two supernumerary teeth erupted in the mid-line whilst his central incisors had erupted very much to the side. He had extracted the two supernumeraries and then extracted the two central incisors, implanting them in the supernumerary sockets which he had enlarged with bone burs. The Class III tendency was much improved. That had now been done just over four and a half years and it was very interesting. Patchy resorption had developed on both these teeth, but he still thought that the operation had been justified as in their new position they had improved the bite and exercised a measure of control over the lower incisors. In fact the Class III tendency was much improved. He had expected to have to extract these incisors after about two years. However, after four years they were still very firm with no sepsis, and might remain so for another two.

The other was a replantation case where he had replanted two very young central incisors which unfortunately had been dislodged; there was galloping resorption of one tooth, which fell out, but the other one was, after five years, still there. It now had no root, and no dentine in the crown, the root and dentine having progressively resorbed and been replaced by bone. The crown looked quite normal in the mouth and was firm as a rock. He had given up trying to forecast the outcome of these sorts of cases in children.

With regard to the epithelial attachment, that obviously must be ruptured, but healing must take place. This had been the least of the problems. As to keeping track of the cases, as they came in they all started on the base-line of the wall-chart and then they were checked and X-rayed every three months so that the chart became self-recording. That was why he had shown the results in that form.

Mr. Kettle was perfectly entitled to his own point of view: he had merely shown the cases in order that people might make up their own minds. He wanted to make it perfectly clear that he was not urging them to rotate teeth surgically.

In reply to Mr. Walpole Day, he said he had quite an amount of data because naturally one had followed cases where severe rotations had been undertaken by more ordinary methods but unfortunately they would take too long to mention at the present time. It was very difficult to get an absolute parallel with most of the type of cases which he had previously shown. As to whether there were more failures by the present method he had not yet got that material properly collated but he agreed that it was important and he hoped to get the results in due course.

In reply to Mr. Wilson he said that was quite true. He thought the central incisors showed less tendency to resorb, but the number of cases was too small, although he agreed that the central incisor had a very much rounder cross section. He thought in the case of the lateral incisor the canine was very often inclined forward and might be a factor in inducing distal resorption. It would be remembered in the examples shown that two or three of the teeth were at right angles to normal and he had thought it was justifiable at that time to turn the teeth by that method.

The Chairman thanked Professor Hallett for his paper and all the members who had taken part in the discussion, whose enthusiasm had shown how interesting the paper had been.

THUMB- AND FINGER-SUCKING

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THERE is a Latin proverb which reads—"Men do more things through habit than through reason".

For the purpose of our discussion a habit may be defined as any definite mode of acting which does not belong to man's hereditary equipment. It is individually acquired. So great can be the force of habit that—

> Small habits, well pursued betimes
> May reach the dignity of crimes.

The habits which are recognized in children have been tabulated as follows by Olson (1929).

1. Oral (sucking thumb, sucking fingers, biting nails, protruding tongue).
2. Nasal (picking nose, scratching nose, wrinkling nose).
3. Hirsutal (pulling and twisting hair, scratching head).
4. Irritational (scratching body).
5. Manual (picking fingers, writhing hands, clenching fists).
6. Ocular (rubbing eyes, blinking eyelids, winking).
7. Aural (pulling ear, picking ear).
8. Genital (manipulating genitalia, thigh rubbing).
9. Facial (grimacing, twitching muscles).

Olson (1929) also studied and recorded the habits of 459 children. The result of this work in the table which follows shows the great frequency of oral habits.

	Frequency of Habit Action
Oral habits	247
Nasal habits	127
Hirsutal habits	105
Ocular habits	69
Aural habits	48
Genital manipulations	17
Habit actions exhibited by 459 children	613

This means that 40 per cent of the habits recognized in this group of children were associated with the oral cavity. Habits associated with the mouth are many and varied. To mention only a few, we have tongue and lip habits, nail biting, and the insertion of foreign objects into the mouth. A very large percentage of oral habits are those of sucking the thumb or fingers. Nord (1955) states that at least 50 per cent of the cases attending his clinic for treatment of malocclusion are thumb-suckers. In a paper read to this Society last year dealing with a survey of 1000 schoolchildren, Gardiner (1956) stated that 27·2 per cent had a history of sucking the thumb or fingers. Lewis (1930) records a study of 170 children, 30 or approximately 18 per cent of whom presented a history of thumb-sucking. Sillman (1951) found 20 thumb-suckers in a group of 60 children. It has been established by different workers that the habit of thumb- and finger-sucking is not infrequent and that in many cases it is, at least, a contributing factor towards the production of malocclusion.

This habit is known to start at varying ages in children and in response to different factors. It is known that before and at birth the hands are in fairly close proximity to the mouth and Salzmann (1943) suggests that when the fœtus shows increased muscular activity, the thumb may find its way into the mouth. In Lewis's (1930) paper we find that 9 out of 30 cases commenced the habit of thumb-sucking at birth, 16 by 2 months, 20 by 3 months, 23 by 6 months, and 28 by 12 months. The remaining 2 commenced the habit, 1 at 18 months and the other at 2 years. From the above figures it will be seen that the largest group commenced the habit at birth or soon afterwards and that the majority formed the habit during the nursing period.

From the moment of birth we find the infant when not sleeping is ceaselessly moving the arms, legs, and head, and indeed the whole body. At the same time there is a feeling of hunger and a desire for food. If during this

Given at the Newcastle upon Tyne meeting held on May 11, 1956.

time the so-called random movements bring the hand to the vicinity of the mouth the infant may commence to suck it. Continue to stimulate him in this way and the movement of the hand towards the mouth becomes more frequent and the child becomes more efficient in selecting a part of the hand which will resemble the nipple or teat. Stimulus can be produced by improper feeding, caused by faults in quality, quantity, and feeding conditions. It may be produced by a feeling of insecurity, due to lack of attention, or fear. In one case examined by Watson and Rayner (1920) they found it much harder to frighten a child when he had his thumb in his mouth.

In a few cases the desire to suck the thumb or fingers may commence at the time of weaning, especially if this process should be carried out suddenly. It has been suggested that the infant requires a certain sucking time, about 2 in every 24 hours, and when this is suddenly reduced he may make up the required sucking time by inserting the thumb or finger into the mouth.

Rachel Sclare (1949) states that "many nervous habits would appear to have a genetic origin. Although the actual habit may not be transmitted by the parent, the child may inherit the nervous and psychological tendencies which are responsible for the development of the habit". Most of us have seen children sucking their thumbs in a manner similar to that previously performed by a parent.

Imitation of an older member of the family or of a playmate may be responsible for some children commencing to suck their thumbs.

No matter what the cause, the formation of the simplest habit is an enormously complicated affair, forming pathways in the brain by which certain outgoing currents always tend to escape. In support of this we observe that children develop a recognizable pattern of thumb-sucking. The habit is performed each time in similar circumstances and in a similar manner. As time procecds the circumstances are slightly modified. After the first year of life we find the habit is stimulated by hunger, tiredness, jcalousy, unhappiness, idleness, and nervous tension. As time proceeds the habit becomes associated with the other habits of the child and may be performed when the hands are idle, for example, when reading and also at bed-time. Because of social customs and the shame which the child is made to feel, the habit in older children is carried out privately or in secret, and in the majority of cases at bed-time. The manner of performance seems to remain more constant. The same digits are used each time the child sucks. It is obscrved that when the thumb is used it is in most cases always the same thumb although there is a small percentage of cases where either thumb may be used. We never find the child substituting another digit if it is not possible to suck the usual one. The thumb is usually inserted in the mouth with the palmar surface towards the palate. It may be inserted to the right, centre, or left of the mouth. It may be inserted until any point from first to second knuckle makes contact with the tips of the lower incisors. The same amount of thumb is always inserted in the same position. When fingers are inserted in the mouth we find an even greater variety of methods. When only one finger is used it is most often the index finger and it is usually inserted into the mouth bent at the second knuckle, or with the palmar surface towards the tongue. When two fingers are used they are usually the index and the middle fingers and may be inserted with either the palmar surface towards the palate or towards the tongue. The child very seldom forms the habit of sucking the two remaining digits. On occasions it has been observed that the thumb and index finger are inserted in the mouth in a pincer fashion. The intensity or vigour of the habit is also variable from individual to individual, ranging from the gentle insertion of the digit into the mouth and a light occasional sucking pressure to the insertion of the thumb or fingers many times a day and very vigorous sucking.

We observe in some cases of thumb- or finger-sucking the presence of a second habit. This may be practised at the same time as the sucking habit either by the remaining fingers or by the fingers of the free hand.

The habits performed in this way include any of the habits associated with the nose,

ears, hands, clothing, or hair. Habits of the tongue and lips have been observed in some cases. These habits are practised at a separate time and are secondary to the sucking habit.

Gardiner (1956) reports that only 39 out of 272 thumb-suckers showed malocclusion which could definitely be attributed to the habit. Lewis (1930) observed a typical malocclusion in 24 out of 30 thumb-suckers. "The fact that some children who suck their thumb do not have a malocclusion depends on the sucking technique and the duration and intensity of the habit as well as whether or not the children in question have well-developed, strongly built jaw bones, which are capable of withstanding the abnormal pressures brought to bear upon them during the thumb-sucking process." (Lawes, 1950.) He also found that "these malformations tend to correct themselves if the habit is broken by the time the child is five years of age, but do not tend to correct themselves if the habit persists". Sillman (1951) states that "during the first four years, vigorous thumb-sucking may cause a displacement of the oral structures. However, this is spontaneously corrected after the activity has been relinquished". This fact, he continues to state, "is proved by the evidence as seen in serial records starting at birth".

The thumb- or finger-sucking habit may produce in the deciduous dentition, depending on the way in which the finger is sucked, a malocclusion which is easily recognized as having been caused by the finger. So typical is this malocclusion that in most cases one is not only able to recognize it on the first visit but also to state which thumb the child is sucking. The nature of the malocclusion is an anterior open bite with some labioclination of the upper incisors and retroclination of the lower incisors. In some cases, the anterior open bite permits tongue-thrusting during speech and deglutition. When this tongue-thrusting habit is present it will persist after the thumb-sucking has stopped. This may continue during the period of the changing of the dentition and thereby prevent the development of a normal permanent dentition.

The most serious cases of thumb-sucking are those cases where intensely vigorous sucking is continued until after eruption of the permanent incisors. Such cases show abnormalities in the dental arches and alveolar support, and probably changes in the shape of the palate and the soft-tissue pattern.

Changes in the Dental Arches.—The effects of thumb- or finger-sucking upon the developing dental arches vary with the intensity of sucking and manner of insertion of the digit in the mouth. When the digit is inserted in the mouth it acts like a powerful lever carrying the weight of the hand and part of the weight of the arm. This lever presses the maxillary incisors labially and may also press the mandibular incisors lingually. When the habit is practised with the arm held close to the body and the thumb inserted almost vertically into the centre of the mouth till the first knuckle contacts the tips of the lower incisors, the upper incisors are pressed forward bodily. Their labial axial inclination is either normal or less than normal. When more of the thumb is inserted it is usually held more horizontally, and this may cause the upper incisors to be more labially inclined than normal or produce either a depression of the incisors or elongation of the posterior teeth. In such cases we find faults in the overbite and overjet. This sucking habit may also cause contraction of the maxillary dental arch, particularly in the canine and premolar region. This is caused by the abnormal contraction of the corner of the mouth against the sides of the dental arches. In some cases a unilateral or bilateral cross-bite may occur. The sucking of the thumb to right or left of the mouth produces malposition of the teeth making contact with the thumb. This may also produce what is called a unilateral mesiocclusion of the maxillary arch.

Changes in the Alveolar Bone.—Following mass extraction of the deciduous teeth, cases have been observed where thumb- or finger-sucking has produced alteration in the shape of the alveolar ridge.

Changes in the Palate.—Swinehart (1938) drew attention to another abnormal force exerted in thumb-sucking, that is, abnormal

muscular pressure of the digit against the palate. We are all familiar with the plasticity of bone. We know that external forces used by certain races during the early developmental period change the shape of the feet or the head. We know that the rise of intracranial pressure in hydrocephalus in infants produces enlargement of the cranium.

thumb pressure (*Fig.* 3). The site of pressure in such cases is in the anterior half of the palate. We have not recognized any palatal distortion when the thumb is inserted almost horizontally into the mouth. In such cases there is a greater spread of the pressure because the thumb contacts almost the whole of the palate.

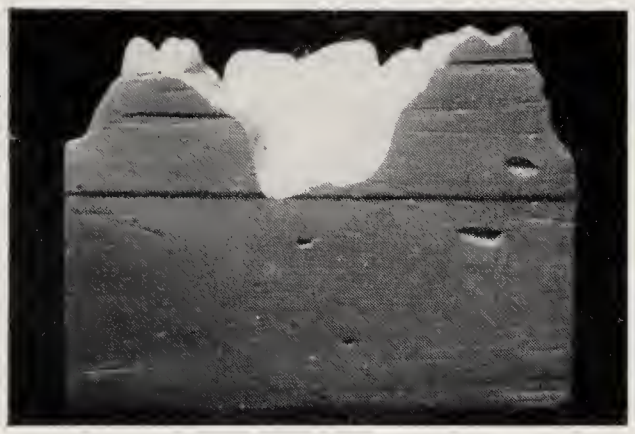

Fig. 1.

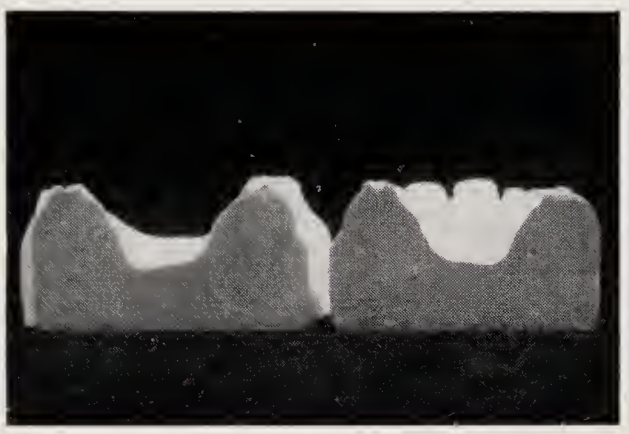

Fig. 2.

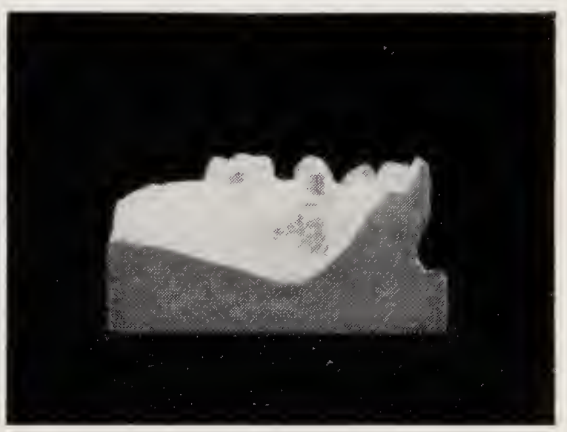

Fig. 3.

Fig. 1.—Abnormalities in the form of the palate associated with sucking the index and middle fingers of the right hand.

Fig. 2.—Changes in shape of palate associated with sucking right thumb. Thumb is inserted on right side of mouth and pressed toward the left of palate.

Fig. 3.—Changes in shape of palate associated with thumb-sucking when thumb is inserted almost vertically into the mouth.

Keith's law states that osteoblasts at all times build or unbuild according to the stresses to which they are subjected.

It is therefore natural to assume that the force of the thumb or fingers which commences in early infancy and continues through the formative period of childhood may be responsible for some alteration in the form of the palate. In many cases under observation we have observed changes in the form of the palate which could be attributed to the pressure of the digit.

In cases where the index and middle fingers were inserted in the mouth with the palmar surface upwards, it has been observed that the form of the palate in the region of contact followed the outline of the tips of the two fingers (*Fig.* 1).

In many other cases where the thumbs were inserted on the right- or left-hand side of the mouth alterations in the form of the palate were observed (*Fig.* 2).

In many cases where the thumb is inserted almost vertically into the mouth a marked palatal distortion can be seen at the site of

Changes in the Soft Tissue.—In a few cases we also observe changes in the soft-tissue pattern which appear to be associated with the sucking habit. The faults are usually in the lower lip and may be in the nature of a curling over of the lip or falling inward of the lip. In many cases we have an accentuation of the labial mental depression.

TREATMENT

Because of the attitude of psychologists and pædiatricians little attention is paid to early treatment or prevention of this habit. The pædiatrician considers that "in infancy thumb-sucking is a normal activity that requires no interference. It usually disappears during the second year when the infant acquires new ways of obtaining pleasure and satisfaction". (Veeder, 1952.) It is now considered by many that the practice of this habit gives no cause for concern unless the child continues with the habit until he is four or five years of age. It is likely that for some time the child has been the recipient of much advice, many scoldings, some nagging, and probably some

persuasion. All this may only cause the entrenching of the habit more deeply in the child and produce an abnormal nervous tension. This, it is felt, should be avoided and a little more attention paid to the prevention of the habit. In this way a large number of cases caused by faulty feeding conditions can be eliminated. When persistent thumb- or finger-suckers present themselves for orthodontic treatment it is after the presence of marked malocclusion or of facial deformity has been recognized by the parent. Attention has been drawn to many of the factors which stimulate the sucking habit, and to the varying degrees of intensity and method of practising the habit. No two cases although they may appear similar are actually alike. Before planning treatment it is essential that a very detailed case history should be taken. Details of the child's family background and information of the inception of the habit are essential. Information regarding previous attempts to stop the habit should be obtained. I find it is usually desirable to ask the parent politely to take no further active part in the treatment. A man-to-man talk with the child is then desirable. On this occasion we show the child, with the aid of models, the damage to his dentition. We also gently boost his morale and then appeal to his will-power. Nothing spectacular is demanded and the child may be given several months to stop the habit. Many children return for their next appointment having stopped the habit. Others do not find it so easy. Still no pressure should be applied. Pressure may force the child to commence some other habit which though not so disfiguring may from a social angle be less desirable. We have known cases commence habits such as stuttering, genital manipulation, sleeplessness, and bed-wetting following an unwise amount of pressure applied by well-meaning parents. Appliances have sometimes to be inserted into the mouth to remind the child that thumb-sucking is an undesirable habit.

One of our cases attending for treatment is a thirteen-year-old girl. Her mother had tried all the known "cures" without success. She continued to suck her thumb at school, when reading, when watching television, and at bed-time. After the insertion of an appliance it took over six months to stop the habit.

SUMMARY

1. Persistent thumb-sucking is found frequently among children and may produce dental and facial deformities.

2. There are many factors which may be responsible for the formation of the habit.

3. When the habit is stopped by four years of age and no secondary habits have developed there should be no malocclusion of the permanent dentition.

4. The intensity or vigour of the habit varies from individual to individual.

5. There are many ways in which this habit may be practised.

6. Abnormalities in the dental arches, alveolar bone, palate, and soft tissues can be attributed to the habit.

7. Attempts should be made by the pædiatrician and family doctor to prevent this habit.

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DISCUSSION

Opening the discussion, *Mr. Leech* said he wished to thank Mr. Munro for his interesting paper, which was mainly bibliographical. Unfortunately as he had received it at a rather late hour his appreciation of the paper was limited to what he had been able to assimilate from the spoken word, and for that reason he apologized if his remarks appeared to take the form of a subsidiary paper. He would have liked to have seen some more statistics shown by Mr. Munro, and in the absence of them he proposed to produce some of his own. His experience was of two hundred children chosen at random from the Upper Respiratory Research Clinic at the Victoria

Hospital for Children, Tite Street, Chelsea. A clinical examination of those children was supported by lateral and postero-anterior radiographs and a history taken from the mother. The average age of the children was 7, the eldest being 12 and the youngest 3. Males, 101; females, 99.

Mr. Leech then showed a series of slides of a statistical nature and made the following observations:—

Of the 200 cases, there were 35 who sucked their thumbs or fingers at some time or another. Up to the age of 2 years all the 35 sucked the thumb; up to the age of 4 there were 30; up to the age of 6 there were 23, and then the numbers dropped quite considerably. Up to the age of 8 there were 8 and up to 10 and onwards there were 3. Most of the children started thumb-sucking at birth and most of the thumb-sucking ceased about the age of 6 or 7. Six of the children sucked their thumbs at night only, and 1 or 2 started later than at birth. There was no relationship to feeding; in those starting later than at birth the sucking was often preceded by a prolonged illness or some mental upset such as another child coming into the family.

A history was taken of the feeding of the thumb-suckers. There were 5 who were fed by bottle only; 6 who were breast-fed up to 3 months, and 8 who were breast-fed up to 6 months, but he had been unable to find any correlation between thumb-sucking and breast-feeding or bottle-feeding. On the other hand it was not easy at times to get a history from the mother of exact feeding habits.

The 200 cases were divided up into skeletal patterns: skeletal I being the normal dental base relationship, skeletal II being the post-normal, and skeletal III being the pre-normal. There actually were less skeletal II's among the thumb-suckers (about 32 per cent) than there were among the non-thumb-suckers (about 40 per cent), i.e., a post-normal apical base relationship was more common amongst the non-thumb-suckers.

Nineteen of the 35 had an increased overjet, but 11 of these were on skeletal II bases anyway. Seven persistent thumb-suckers had perfectly normal occlusion. Sixteen of the 35 had a reduced overbite or actual open bite and most of these had an associated anterior tongue thrust.

Mr. Leech said his general conclusions were that thumb-sucking was undoubtedly a factor concerned in the creation of malocclusion but a factor which had been emphasized out of all proportion to all other factors. He personally would place it very low down in the aetiological scale. It seemed to have little effect, if any, on the growth of the jaws, the deformities being limited to the alveolar structures, of which an anterior open bite seemed to be the most common. If the habit was given up before the permanent dentition erupted then it seemed to have very little effect; if it persisted after the eruption of the permanent dentition, cessation of the habit would in most cases result in a natural disappearance of the deformity, provided that the soft-tissue behaviour was normal, but appliance therapy as described by Mr. Munro might be needed.

The role of thumb-sucking and tongue-thrusting in the actiology of malocclusion was a confusing one: it seemed that the one might be a principal factor whilst the other was secondary. His own view was that the thumb-sucking might be the prime factor with the tongue moving into the open bite thus created.

In many children who were not thumb-suckers there frequently occurred, after loss of deciduous incisors and before the eruption of the permanent incisors, a gap into which the tongue moved. Conversely the tongue thrust might be the prime factor causing the malocclusion, and the thumb-sucking the secondary factor in enhancing it. Most abnormalities previously attributed to thumb-sucking were really due to an inherent abnormality of the skeletal pattern and/or of the surrounding soft-tissue behaviour.

As regards the treatment of the persistent thumb-sucker, his own view was that it should be directed mainly towards the discovering of the emotional factor concerned, and it should be dealt with by tact and kindness rather than by punitive measures, the latter nearly always producing the opposite result. In most cases treatment was not necessary, except in the really persistent thumb-suckers where a bad malocclusion was being produced.

Mr. Walpole Day said he would have liked to have heard a few more remarks about the cause of thumb-sucking. When one looked round there appeared to be more thumb-sucking in the so-called civilized races, and when one sought an explanation it appeared that thumb-sucking habits were associated with boredom and that they probably started through hunger, and it was interesting to speculate on whether there was something wrong with the method of the feeding of the very young child. One knew the horror with which a nurse would greet any suggestion of extra feeds and how she would say "No more food till ten o'clock", which makes one wonder whether four-hourly feeding was entirely a good thing. A hungry child with a small stomach might need more frequent feeds, and it was interesting to note that in America now they were breaking away from the four-hourly feeding system and feeding the child more often and more when it was wanted.

Mr. R. A. Campbell expressed his appreciation of the paper Mr. Munro had given and the subsidiary paper by Mr. Leech. One factor on which he would like to hear Mr. Munro expound a little further was that of the co-operation of the general practitioner and the pædiatrician. At the present time the tendency was to treat the subject of thumb-sucking as being relatively unimportant, and it seemed that such an attitude on the part of the medical profession would have to be overcome. Even more important was the attitude of the parent and whether it was possible to present them with some rationale for prevention, and that was a point on which he would like to hear a good deal more.

There was one thing that he had noticed with great interest, not only in his own family but among his friends in Australia, where he came from, and that was that over the years there had been developed a method of putting the child down between feeds for sleeping purposes, and so on. That method, which had not been invented to prevent thumb-sucking, was in fact a very good deterrent in the early stages when the habit normally commenced, and not being a mother himself he could only define it as swaddling the child. The child was in fact completely wrapped, with the hands more or less at the sides, and that in itself appeared to be one of the greatest deterrents it was possible to devise.

Mr. Breakspear said he had noticed that palatal abnormalities could occur without any thumb-sucking at all and he hoped Mr. Munro would follow up his investigation by studying a number of cases of non-thumb-suckers to see whether such abnormalities were found more among one group than the other.

Mr. Hellier said Mr. Munro had quoted somebody as saying that the abnormality as a result of the thumb-sucking might be very much less if the bony structure was strong enough to resist it, but his own personal feeling was that the explanation of that would be that the lack of abnormality, or the good position of the teeth, would arise more from the countering influence of the muscles which resisted the action of the thumb, and not necessarily the strength of the bone. He continued by saying that he had seen cases of thumb-suckers in skeletal Class III where the habit had been beneficial and patients had reduced an abnormality quite unconsciously, by bringing the erupting incisors into labial occlusion.

Mr. Kettle said he felt grateful to Mr. Munro for giving such a delightful series of pictures and putting the problem in a very orderly manner. He wondered whether anyone had ever heard of a real objection to the use of the dummy or comforter which could be rejected quite simply in the first three or four years of life.

A point had been raised in the discussion about such habits in what might be called the "uncivilized races". He seemed to remember reading of an African tribe where suckling went on until the age of nine or ten, and it was interesting to speculate on whether that caused a gross malocclusion!

Mr. Gray thanked Mr. Munro for putting in their possession a full survey of the whole problem of thumb-sucking and its attendant troubles. The correction of those habits in the young child would very often automatically put the condition right, and the point about not scolding the child was terribly important. The child should never be punished for the habit but if he or she could be reasoned with the habit could frequently be checked. However, when it became a matter of orthodontic treatment and the molars had erupted it was a very simple matter to fit a fixed appliance, and almost overnight the habit would stop in 99 per cent of the cases.

Mr. Littlefield said that the subject of thumb-sucking was one which had interested him for some years. With regard to the aetiology of thumb-sucking, there seemed to be an inherited predisposition but that was not the only cause. During early years of life the main cause seemed to be, not so much a lack of food, as a lack of sucking activity on the part of the child. Then, in later years, his experience was that thumb-sucking generally resulted from a lack of harmony between the child on the one hand and his environment on the other. Either the child might be at fault, or the environment, or both.

With regard to the misunderstanding with the medical profession about thumb-sucking, that had been aired in that part of the country quite recently at a brains trust. His own view was that the misunderstanding had arisen as a result of the old type of treatment of thumb-sucking, where the habit was forcefully ceased by orthodontists and where complications, such as stuttering, were sometimes produced. It was not so much that the medical profession regarded thumb-sucking as incapable of producing harmful effects but that they disapproved of its forceful cessation. Their view was that the forceful cessation of the habit might produce complications which, in themselves, were often more harmful than the original thumb-sucking. He believed that, if orthodontists were to explain to the medical profession their modern methods of treatment of thumb-sucking by logical approaches to the patient and the parent, the misunderstanding would no longer obtain.

Professor G. E. M. Hallett said that he wished to support what Mr. Littlefield had said because for some reason thumb-sucking seemed to be a "seconds out of the ring" topic. No one had mentioned that a child sucking his or her thumb over a prolonged period was not a very dignified sight and he would have been very disturbed if one of his own children had indulged in such a habit beyond the age of four; fortunately he had not had any trouble of that nature at all. But it was not a dignified act and later on if children were allowed, or even encouraged, to continue with thumb-sucking because of the alternative risk of inducing some other psychological disturbance as a result from interfering with the habit there was still the fact that at school or elsewhere they would be recognized as thumb-suckers by their fellow school mates and sheer self-consciousness bring its own undesirable psychological aftermath. He had seen many malocclusions which seemed to be directly attributable to the way in which fingers and thumbs were sucked, and, though in company with everyone else present he strongly deprecated the "barbed-wire" and arm binding techniques which were physically restrictive, he could not see any reason for not attempting, on a very light and friendly basis, to get rid of the habit. The dentist could establish the right sort of "rapport" for this more easily than the parent and in most cases the child was only too anxious himself to stop. By treating the whole thing in a matter-of-fact way, by sometimes giving another appliance to suck in substitution, he found that in most cases the habit was broken quite easily though eventually one was left with a very few intractable ones. The children were the happier for it and the orthodontic treatment, if necessary, was much simpler.

Mr. H. Richards asked whether Mr. Munro had noted any cases in which the malformation could be attributed solely to the thumb-sucking habit.

Whilst he had no statistics, his impression was that the thumb caused trouble largely in the type of case which was an orthodontic problem anyway.

The Chairman said that there were obviously two basic schools of thought on the thumb-sucking question: there was the school of thought which considered it to be the root of all evil and should be stopped, if not at all costs at least at fairly considerable cost, and there was the school of thought which considered that thumb-sucking, except in rare cases, produced gross dental abnormalities only where there were other factors present. He considered that the Class I, Division 1 malocclusion was there from the beginning, and that therefore the latter was the school to which he belonged. There was another way of looking at the problem, which was that in the Class II, Division 1 cases which came along at the age of about 11 or 12 when they were asked about their thumb-sucking habits it was astonishing how few of them had sucked their thumbs beyond the age of from 4 to 5 years. In the Class II, Division 1 category in a very high percentage of the cases thumb-sucking was not an aetiological factor, but when one took the cases which had not sucked their thumbs it would be found that they had incompetent lips, or a markedly atypical swallowing action, which was tending to push the incisors, and if one then added the factor of thumb-sucking which also pushed them forward that then determined the case.

He was surprised that nobody had mentioned the use of an Andresen appliance, because not only did it control thumb-sucking in a way which was completely innocuous

but also it might be made to adjust the relationship of the incisors, which might be made worse by the thumb-sucking.

Mr. D. Munro, in reply, thanked all those who had taken part in the discussion for the points which they had raised. He quite agreed with Mr. Leech that the paper was mainly bibliographical rather than statistical, but he thought he need make no apology for that. Indeed had it been otherwise Mr. Leech would probably have been deprived of the opportunity of showing his statistics! Mr. Leech's next remark had been to state the same thing that the President had just suggested, that the skeletal Class II cases of malocclusion were not the result of thumb-sucking, but personally he had been careful not to mention that. If he had gone a little further he would have quoted such people as Humphries and Leyton, who suggested that they had found a number of thumb-suckers amongst the Class II cases which they had investigated, and Johnstone, who had suggested that thumb-sucking might prevent Class III cases. He was not at all sure about that himself and therefore he had kept it out of his paper. The point of bottle- and breast-feeding had also arisen and he had been interested to note that 30 of the cases shown by Mr. Leech were breast-fed and only 5 bottle-fed. That was extremely interesting because one or two people had suggested that probably the bottle-feeding was responsible for the malocclusion. It was also notable that in the figures as to when the feeding stopped, the largest group consisted of those who were allowed to feed until 9 months. It had also been suggested by one or two people that the longer the child kept sucking the more likely he was to have a sucking reflex, and when that stopped he was likely to substitute the thumb. On the other hand there were some workers dealing with a group of children breast-fed, bottle-fed, and cup-fed, and it was interesting that in their statistics they found there was a higher percentage of thumb-suckers among the breast-fed children than among the bottle-fed and higher among the bottle-fed than among the cup-fed children.

Mr. Munro said he agreed with Mr. Leech that probably it had no influence upon the growth of the jaws. An interesting point which he had hoped someone would make some comment on was the alteration in the form of the palate.

Mr. Walpole Day had raised the matter of aetiological factors and he thought he had dealt with that in the paper but probably he had not gone into it at large. With regard to the "civilized races" he was not in a position to say very much about them at all! Mr. Day had also spoken about feeding faults and had mentioned the four-hourly feeding and the American alternatives to that: in this country we had the two different feeding times—four hours and three hours—and usually the feeding times were assessed from the requirements of the child very early on. His own view was that feeding faults were extremely important and that was why he had mentioned that something could be done about the malocclusion, particularly if attention was paid to feeding faults, and one could go on for quite a long time on that point alone. He had previously suggested that feeding faults were obvious in quantity, quality, and method of feeding, and it had been found that the quality of the feed could be just as variable in breast-fed as in bottle-fed children. In the bottle-fed child it was possible to experiment with it and eventually to get the required quality. With the breast-fed child it was not so easy to adjust it, and in fact in many of the cases which he had had under observation it had been found that the children began sucking the thumb at about three months of age. At this time their mother was short of milk and had found it necessary to change the feeding of the child from the breast to the bottle because the child was not getting sufficient feed or the right quality, and hence those two things seemed to be associated.

Mr. Campbell had suggested the co-operation of the family doctor and the pædiatrician in helping to prevent the thumb-sucking habit. He hoped he had previously made the point clear that he personally would like to see a little more co-operation. In general the medical students were taught that the habit was unimportant and that the child should just be left to suck his thumb and that he would ultimately grow out of it. It was perfectly correct that in many cases the children did grow out of it, but it was those cases which did not stop before four years of age that the orthodontist was particularly interested in, and if it were possible to prevent the sucking habit in such cases it would reduce the incidence of malocclusion.

With regard to methods of prevention, undoubtedly one such method was an investigation of the feeding method as well as the quantity and quality. Many mothers were very careless about the feeding methods which they used and considered that they could do something else as well as feed their baby. Not infrequently they carried on a conversation with other people in the room if the child was being bottle-fed, and his own view was that such a habit was to be discouraged. If the child could be fed in private it was far better, where everything was quiet and the child could then concentrate on his sucking.

With regard to the method which Mr. Campbell suggested was used in Australia, namely that of wrapping the child up, strangely enough that did not appear to be encouraged in this country as far as he could find out. He had children himself, and Professor Hallett had mentioned his, and none of them had sucked their thumb and those children had always been wrapped up well, but whether that was of any importance he was unable to say. Admittedly he had come across cases where the child had been well wrapped up during sleeping periods but had developed the habit of sucking the thumb, and it certainly might be a factor which was worth considering.

Mr. Breakspear had then asked whether the palatal abnormalities could not be attributed to some other cause, and he hoped when presenting the paper he had not suggested that the sucking of the thumb was the only way by which one could get abnormalities in the palate. It would be far from his real idea of things if he had let them think for a single moment that the thumb-sucking was the only cause of palatal abnormalities, because it was not.

Mr. Kettle had mentioned the dummy or comforter, and that was a matter which must always come up in a discussion on thumb-sucking—the pros and cons of sucking a dummy instead of sucking the thumb. Personally he would agree with it if it was observed that the child had a tendency to suck the thumb, and if there was no other way of stopping the child then he might be given a comforter because it seemed that the malocclusion resulting from sucking the comforter was less than that resulting from sucking the thumb and therefore it should be used instead of the thumb. Also it was possible to remove the dummy or to try to discourage the use of

it much more easily than trying to discourage the use of the thumb.

Mr. Gray had stressed the point of not scolding the child and he agreed that was very important. His own experience was that the children who sucked their thumbs were usually very intelligent but as a rule their morale had been considerably reduced by all the scolding which they had had in the past, and probably the whippings, too, and therefore the first thing he did was to try to boost their morale, and he found that was very successful. He also suggested to the parents as politely as he could that they should leave the matter to him as the case was now between the child and himself. Like Mr. Gray he had inserted an appliance and overnight the sucking habit had stopped on many occasions; Mr. Gray suggested 90 per cent of the cases and probably he was correct, but there were the other cases where that just did not happen and one had to go a little further.

Mr. Munro said he had expected Mr. Littlefield to contribute something to the discussion because he knew of his great interest in the subject, and he agreed with him that probably the basis of the majority of cases was the disharmony between the child and his environment. That could occur in very many ways such as the method of feeding, and another important factor in the disharmony was the surroundings of the child—the family life, and so on, which were very important.

Professor Hallett had elaborated a little on one or two of the points and had given his opinion on them. He considered it an undignified act, and that was the usual sort of attitude to it. Certainly it was more than undignified—it was unhygienic. That was probably one of the big factors to be considered in the matter—the undignified act as Professor Hallett called it—because social customs were responsible for that attitude. In many ways it was no more undignified than some of the other habits that the child might indulge in. The psychologist differed from the orthodontist on his attitude to this point. The psychologist said it was no more important than other habits which could be just as socially wrong as thumb-sucking. The fact was, as far as the orthodontist was concerned, that malocclusion seemed to be present and thumb-sucking was a factor in the consideration of malocclusion in very many cases. He agreed with Profcssor Hallett in regard to his casual attitude regarding the cases: the child should never be made to feel embarrassed when speaking to the orthodontist because the latter might be the only real friend the child had and such relationships should be retained. That was the only way in which one could succeed with such cases.

Mr. Richards had then mentioned the point that orthodontic problems were present as well as the habit of thumb-sucking in the cases where malocclusion was produced. It was true that one did get malocclusion of the arches and a whole lot of factors present, but there were also many cases where there seemed to be no other cause of producing the malocclusion than the thumb-sucking.

A point arising from the Chairman's remarks was the use of the Andresen appliance. That was certainly one of the appliances that could be used, and he understood that one of the first occasions upon which Andresen had used the method was in order to treat the thumb-sucking in his own two- or three-year-old daughter.

The Chairman said Mr. Munro's remarks about habits of feeding had reminded him of one occasion in India upon which he saw a woman on a station platform feeding her rather elderly child, both of them at the same time smoking cigarettes!

A vote of thanks to Mr. Munro for his paper and his reply to the discussion, proposed by the Chairman, was accorded with acclamation, and the Session then terminated.

THE MANDIBULAR CONDYLE

FIFTY CASES DEMONSTRATING ARREST IN DEVELOPMENT

D. GREER WALKER, M.B., B.Ch., M.D.S., F.D.S. R.C.S.

THERE are many well-known names connected with the development of the mandible. In the prenatal period Low (1909), Fawcett (1925), and Wilson Charles (1925) are but a few whose works are frequently quoted. In the later stages of development the name of Brash (1924) has occurred more frequently than any other. He was not only conversant with all the previous work but laid the foundations for much of the present-day research. Both Brash and Keith (1948) thought that special X-rays of the growing child might add considerably to the knowledge already attained. In this field the names of Broadbent (1931), Brodie (1941), Tweed (1946), and Margolis (1947) stand out as some of the early workers. This work has, however, met with some disappointments. The time-old problem of "fixed points" has once again been apparent. Keith, speaking on this point during a discussion of Brash's work (1926), stated that everything was moving and nothing was fixed.

In this country Rix (1946), Ballard and Gwynne-Evans (1948), Hovell (1950), Walther (1954), and Tulley (1952) have turned their attention to what they prefer to call soft-tissue morphology. These workers feel that not enough attention has been given to the part played by soft tissue in facial development.

It is not my intention to discuss these works but rather to draw your attention to a study of some 50 cases demonstrating the importance of the condylar cartilage in the development of the mandible. In all these cases this centre of growth has been damaged in some way after birth. Heretofore there have not been many papers on this subject. I must mention Rushton (1944, 1948) who has constantly insisted on the importance of this centre of growth. Engel and Brodie (1947) reviewed 19 cases of condylar upsets in development. In this number they included some congenital deformities. I do not propose in this paper to discuss the prenatal cases. Sarnat and Engel (1951) carried out some valuable experimental work on the Rhesus monkey, removing the condyle on one side. Their conclusions are parallel with mine.

Fig. 1.—The under-developed site is stippled and the teeth are white : this side is superimposed upon the opposite mandible which is unaffected.

In this series of 50 cases there were 39 with unilateral condylar interference and the remaining 11 cases demonstrated bilateral condylar arrests in development. I have subdivided the unilateral cases into three groups. The first, those resulting from middle-ear disease, the second from some form of trauma, and the third from some form of mandibular infection or the result of radiotherapy. Many writers have long recognized these causes as the responsible factors that can damage the condylar cartilage. A detailed analysis of the cases is given in *Table I.* Murphy (1914) writing on ankylosis of the temporomandibular joint listed four causes: middle-ear disease; mandibular osteitis; a metastatic arthritis; and trauma. He drew attention to the importance

Read at the Newcastle upon Tyne meeting held on May 11, 1956.

of the condylar growth centre. Brophy (1916) reported Blair as finding that 50 per cent of his cases were of traumatic origin and he quotes Orlow's figures for trauma as 29·4 per cent. In my series I found that out of 39 cases of unilateral derangements 11 cases arose from middle-ear infection, 14 cases from osteomyelitis, etc., and the remaining 14 were the result of trauma. It must be remembered that nowadays there are likely to be less infective cases but unfortunately this may well be counteracted by the increase in those resulting from trauma. MacLennan (1952) writing on 180 cases of fractures of the condyle found that 2·78 per cent occurred in children under 10 years and 6·11 per cent under 15 years. These figures do not include crush injuries which have been mentioned by Dufourmontel (1929) and Rushton (1944). This is, I think, a very important factor. At any early age the condylar cartilage is very vulnerable and I am sure trauma to it accounts for more agenesis than we realize. I have formed the opinion that gross deformities can result from damage of the condylar cartilage up to the age of 6 years, thereafter the deformity is slight on the whole apart from the case that is basically a skeletal Class III. In this prognathic jaw at even a later date gross deformities can occur. I have been unable to find any change in the size of the teeth or their eruption, except of course for the lack of molar room. In some of the severe arrests in development the third and second molars are placed in the ramus.

The cases arising from middle-ear disease suggest that the arrest in development has been a very gradual process. So also has been the limitation of gape resulting from the intra-articular infection. Two cases showed no limitation of gape at all, but it is interesting to

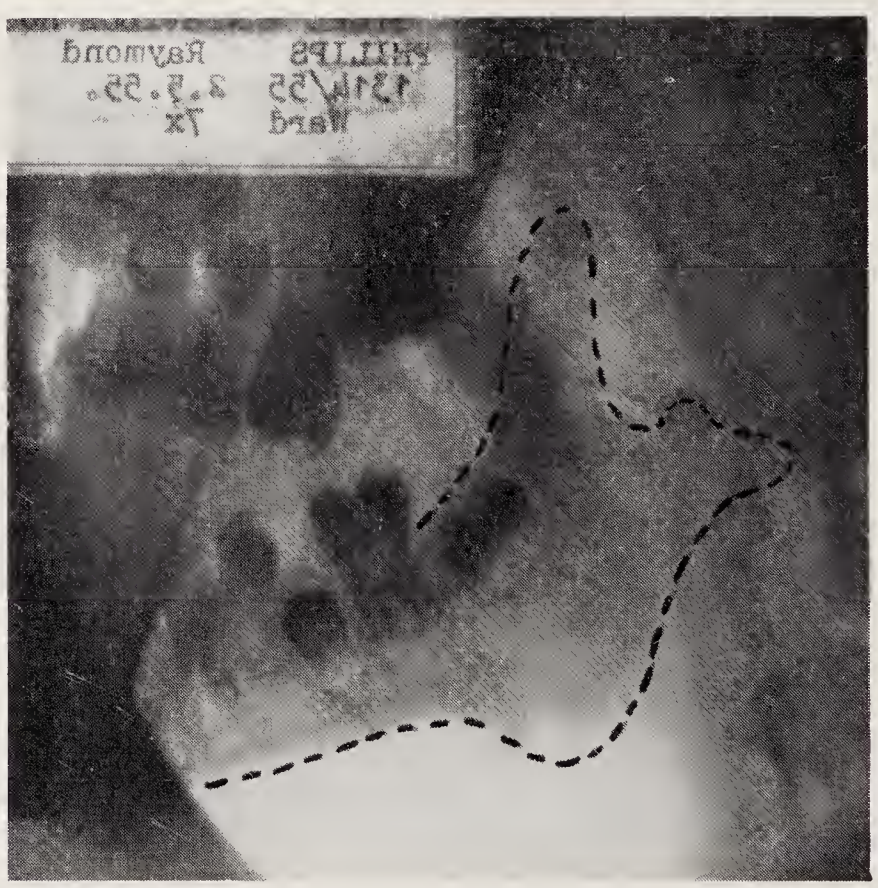

Fig. 2.—This patient was 8 years of age. At the age of 4 years he was involved in a motor accident, and the left condylar growth centre has been damaged.

note that in both cases the history was vague. Both suffered from middle-ear disease and there was no history of trauma or osteomyelitis. The limitation of gape in the other 9 was variable; a condylectomy was performed for 6 cases, the remaining 3 though restricted had adequate movement. Perthes (1932) has commented upon the fact that if the jaw is ankylosed on one side it does not necessarily follow that the other joint will suffer damage. Professor Kilner has often stated that in cases of unilateral ankylosis the surgeon must be prepared at the same operation to proceed and remove the second condyle, in other words, treat the case as one of bilateral ankylosis. Two cases in this subsection required a bilateral condylectomy, that is the removal of the one condyle fixed as a result of the middle-ear disease, and the other joint secondarily involved possibly by the prolonged immobilization. It is interesting to note with regard to the latter that development has proceeded in spite of the secondary changes and this gives the answer in establishing whether the case is a unilateral or bilateral development arrest. *Fig.* 1 illustrates the typical case—it will be noted that the condylar centre is solely damaged and there is no interference to appositional bone growth.

The next group of condylar arrests resulting from trauma are similar in that only the condylar cartilage is involved (*Fig.* 2). In contrast, however, only 2 cases showed severe limitation of gape necessitating condylectomy. This can readily be explained by the different aetiology. Dufourmontel (1929), Perthes (1932), and Round (1933) are but a few who have reported fractures occurring in children. John Hallam (1956) tells me that he has seen approximately 2 cases under 5 years of age per year. Ronald Thexton (1956) has sent me the notes of a child who at the age of $4\frac{1}{2}$ years sustained a bilateral fracture of the condyles. This is the youngest child I have seen with this fracture. Dufourmontel thought that the condyle in the young child being short and more straight was less liable to fracture and therefore more easily crushed. Rushton (1944) has pointed out the extreme soft nature of the growing centre and the ease with which a "crush injury" can occur. It would seem that after the age of 5 years the condyle will in all probability fracture at the neck. Before this age the damage will be more in the nature of a "crush injury". In a previous paper (1942) I was under the impression that ankylosis following trauma was possibly assisted by infection. This I now believe to be incorrect

Table I.—Analysis of 50 Cases

1. *Unilateral condylar derangements*	39 cases	
a. Arising from middle-ear infection		11 cases
b. Arising from osteomyelitis, etc.		14 cases
c. Arising from trauma		14 cases
2. *Bilateral condylar derangements*	11 cases	
a. With ankylosis		8 cases
b. Without ankylosis		3 cases

Analysis of 11 *Cases of Unilateral Middle Ear Infections*

Name	*Age at Time of Infection*	*Mastoid Infected*	*Limitation of Gape*	*Degree of Deformity at Age*
J. E.	6 yr.	L.	Severe	Slight 23 yr.
M. R.	15 mth.	L.	Severe	Marked 9 yr.
S. R.	11 yr.	L.	Severe	None 19 yr.
J. T.	?	L.	None	Marked 22 yr.
R. C.	7 yr.	L.	Severe	None 12 yr.
N. W.	$1\frac{1}{2}$ yr.	R.	Severe	Marked 9 yr.
V. M.	3 yr.	R.	Severe	Marked 24 yr.
P. L.	5 yr.	L.	Severe	Slight 24 yr.
P. P.	?	L.	None	Slight 14 yr.
V. P.	3 yr.	R.	Very severe	Marked 22 yr.
K. MeK.	4 yr.	R.	Very severe	Marked 23 yr.

Analysis of 14 *Cases of Unilateral Mandibular Infections, etc.*

Name	*Age and Nature of Infection*	*Side Affected*	*Limitation of Gape*	*Degree of Deformity at Age*
M. D.	18 months extensive infection R. side of face	R.	Severe	Marked 22 yr.
R. M.	6 wk. osteomyelitis of mandible	R.	None	Marked 15 yr.
P. S.	4 yr. osteomyelitis of mandible	R.	None	Marked 13 yr.
G. B.	3 yr. osteomyelitis of mandible	R.	None	Marked 9 yr.
L. E.	2 yr. osteomyelitis of mandible	L.	Severe	Marked 5 yr.
E. C.	2 wk. septicæmia	R.	Severe	Marked 11 yr.
R. P.	2 yr. osteomyelitis of mandible	L.	Severe	Marked 19 yr.
L. M.	5 yr. osteomyelitis of mandible	L.	Severe	Marked 19 yr.
T. T.	2 yr. osteomyelitis of mandible	L.	None	Marked 7 yr.
L. M.	2 yr. osteomyelitis of mandible	L.	None	Marked 26 yr.
M. D.	12 yr. osteomyelitis of mandible	R.	Severe	None 24 yr.
E. B.	4 yr. radiotherapy	R.	None	Marked 15 yr.
L. W.	6 mth. radiotherapy	R.	None	Slight 12 yr.
P. S.	7 yr. septicæmia	R.	Severe	Marked 34 yr.

Analysis of 14 *Unilateral Traumatic Cases*

Name	*Age and Nature of Trauma*	*Side Affected*	*Treatment*	*When First Seen or Period of Follow-up*	*Degree of Deformity*	*Limitation of Gape*
J. O.	5 yr.: fracture condyle	L.	Intermax. fixation	Immediately. Follow-up $1\frac{1}{2}$ yr.	Slight	None
R. P.	4 yr.: road accident	L.	None	First seen age 8 yr.	Marked	None
C. E.	6 yr.: fracture condyle	R.	Intermax. fixation	Immediately. Follow-up 8 yr.	Slight	None
J. P.	4 yr.: blow on jaw	R.	None	First seen 3 yr.	Marked	None
L. W.	8 yr.: fell downstairs	R.	None	First seen 18 yr.	Marked	Severe
M. W.	$2\frac{1}{2}$ yr.: fell downstairs	L.	None	First seen 20 yr.	Marked	None
W. R.	4 yr.: fell from bed	R.	None	First seen 30 yr.	Marked	None
A. B.	? age: road accident	R.	None	First seen 31 yr.	Marked	None
B. M.	8 yr.: kick on jaw	L.	None	First seen 14 yr.	Marked	None
D. C.	6 yr.: road accident	R.	None	First seen 9 yr.	Marked	None
A. H.	6 mth.: deformity noticed	L.	None	First seen 6 yr.	Marked	Severe
E. R.	5 yr.: fracture condyle	R.	Intermax. fixation	Immediately. Follow-up 3 yr.	None	None
A. M.	5 yr.: fracture condyle	R.	Intermax. fixation	Immediately. Follow-up $1\frac{1}{2}$ yr.	Slight	None
J. C.	Unknown. (No history of infection)	R.	None	First seen age 9 yr.	Marked	None

Analysis of 11 *Cases of Bilateral Condylar Under-development*

Name	*Age and Cause*	*When First Seen or Period of Follow-up*	*Degree of Deformity*	*Limitation of Gape*
P. D.	3 yr.: fell 10 ft.	First seen age 7 yr.	L. more marked than R.	Almost complete
P. C.	Unknown	First seen age 15 yr.	L. more marked than R.	Almost complete
C. B.	Unknown	First seen age 22 yr.	L. more marked than R.	Very severe
W. P.	3 yr.: fell downstairs	First seen age 32 yr.	L. more marked than R.	Almost complete
A. M.	6 yr.: fell from window	First seen age 11 yr.	R. more marked than L.	Marked
L. L.	Unknown	First seen age 14 yr.	L. more marked than R.	Almost complete
H. A.	Unknown	First seen age 42 yr.	L. more marked than R.	Almost complete
P. P.	14 yr.: kicked on jaw	First seen age 23 yr.	R. more marked than L.	Almost complete
J. H.	10 yr.: R. fracture of condyles	Immediately: interdental fixation. Follow-up 11 yr.	Both sides appear to be equally involved	No limitation
M. S.	Unknown	First seen 30 yr.		
J. D.	Unknown	First seen 25 yr.		

and I think one of two processes may happen which causes the fixation. The first is that the glenoid fossa may become fused with the union of the bony fragments. This would of course be only possible in the case of a fracture dislocation. The second is that the condylar growth may be partially arrested, that is to say, that the central portion of the cartilage sustains the main damage whilst the periphery

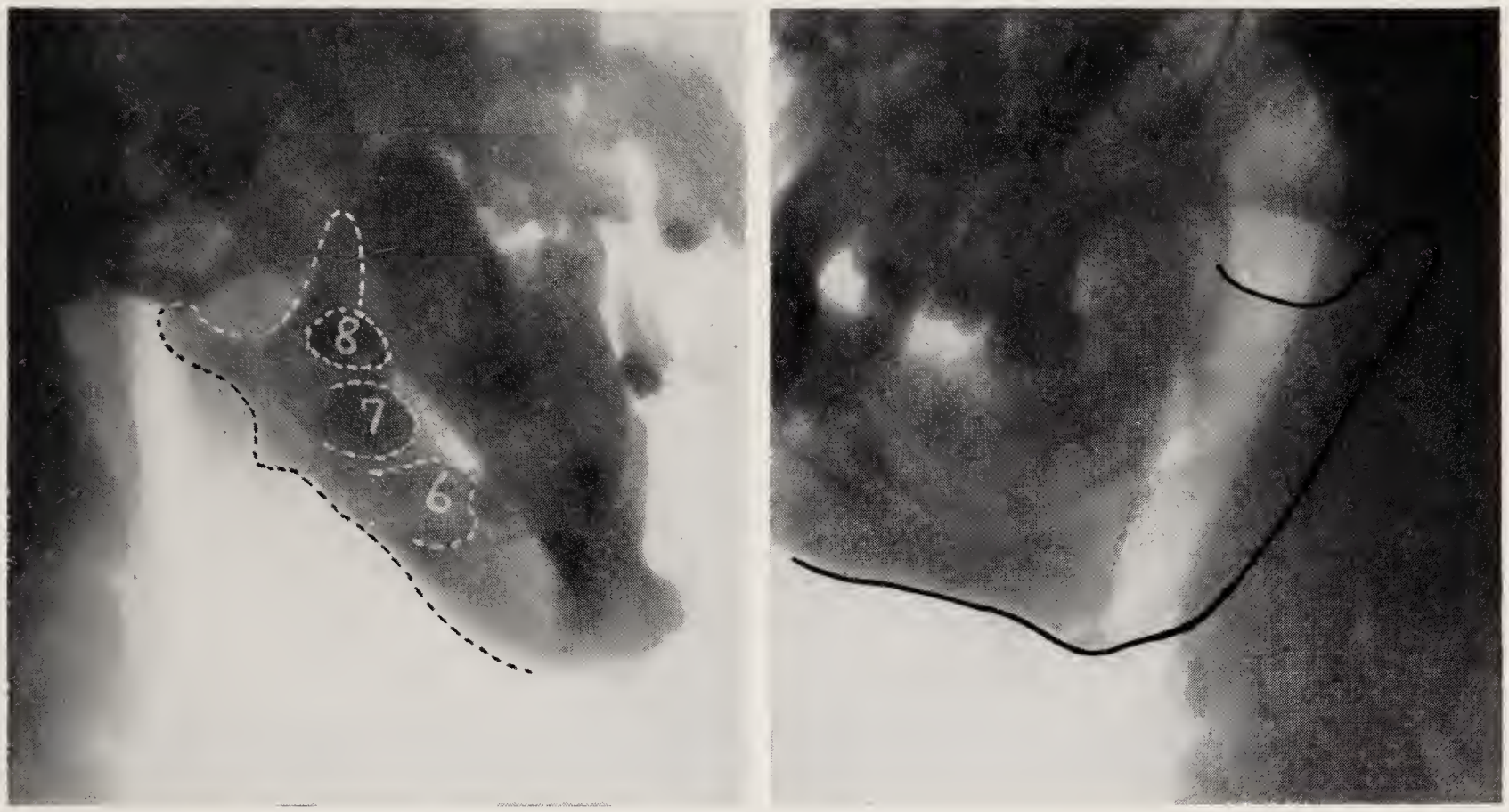

Fig. 3.—The patient was 15 years of age. He sustained a severe infection of his right mandible at the age of 6 weeks. If it is compared with the opposite side it is quite obvious that little or no growth has taken place.

escapes. This could well account for the "mushroom" appearance of the condyle so commonly seen in these cases. This distorted growth could produce a mechanical limitation in the early stages and later lead to a complete bony fusion. In some cases the limitation is early in its onset and might well be due to the former whilst other cases pass a considerable time with gradual increasing limitation accounted for by the latter explanation.

The last of the unilateral cases—those arising from osteomyelitis or the result of radiotherapy—are different from the two former sections in that the extent of the maldevelopment can be so variable. The most severe suggest the "frozen ramus" where it would appear that all appositional bone growth is also destroyed (*Fig.* 3). This case must be carefully distinguished from the congenital cases which I hope to discuss in a later paper. The large proportion of this section results from some form of mandibular infection in the young child. I cannot help repeating my view expressed some years ago (1947) that great care ought to be exercised in treating these infections in the early stages. Many of the cases originated from a simple dental abscess. The main cause for the arrested development was some form of osteomyelitis: 2 cases resulted from septicæmia and 2 were the result of radiotherapy. The latter can of course produce a much more extensive arrest in development, not only condylar, but all the bones in the area. The effects of radiotherapy on developing bone are well known and need no further mention, but there is one particular aspect that might be worthy of further consideration. It is that certain developing centres are more active at certain times than others and further that a maximum development of a bone occurs at a certain stage. One wonders whether it would not be wise—in cases where delay is possible—to postpone this form of treatment until the maximum growth stage is passed. I have, for example, said in this series that all the gross deformities with one

exception originated from condylar damage before the age of 6 years.

Turning to the bilateral cases, I have only included those cases which have definitely a primary bilateral condylar arrest in development. I have pointed out previously that

Fig. 4.—The postero-anterior view of the mandible shows the atrophic changes in the condylar region.

in the unilateral cases there may be secondary fixation in the other joint. There is no apparent upset in development following this secondary fixation. The bilateral cases can very quickly develop a limitation of gape and require condylectomy at an early date. There were only 5 cases with a definite history of trauma; in the remainder it was impossible to elicit the cause. I think that the most likely cause is some injury sustained early in life and this has passed unnoticed. This injury may cause some distorted growth as previously mentioned, the limitation of gape occurring early or at a later date. It will be noticed on studying these cases that there may be a difference between the right and left sides suggesting that the degree of damage to the growing centre can vary. The characteristic of this group is the absence of chin. All this group showed limitation of gape except 3; in these there was perfectly free movement. These 3 cases tended to show atrophic changes in the condylar region as opposed to the other cases which demonstrated more productive changes (*Fig.* 4). In a previous paper (1942) I referred to hyperæmic decalcification following a fracture dislocation and it may be that these cases can be visualized as arising in such a manner. I feel, however, that some more work is needed on this question.

Professor Lucas is in the course of preparing a paper on the study of many of the condyles included in this paper. His observations will I understand be shortly published.

CONCLUSIONS

1. The Primary Deformity.—There is no doubt that the observations of Brash, Rushton, Brodie, and others are correct. *The condylar cartilage is the major factor in mandibular development.*

If this centre is destroyed then all downward and forward growth ceases. If we superimpose the X rays of the arrested side upon the growing side the answer is the same in all cases. I have assumed in these post-natal cases that there is no difference in the position of the glenoid fossæ. The glenoid fossa has therefore been taken as a moderately fixed point and *Fig.* 1 demonstrates the result. I have already mentioned that the worst deformities occur early in life and little or no change occurs after 6 years of age except in the skeletal Class III cases.

2. The Secondary Changes in the Mandible.—It has been pointed out on many occasions that the growing side will cross the midline to compensate for the partial arrest in development. This accounts for the typical clinical pictures so often described with the flattening occurring on the normal side (*Fig.* 5). *There is, therefore, a change in the so-called "basal bone" brought about by failure in condylar development.*

3. The Secondary Changes in the Alveolar Bone.—It is natural to suppose, and in fact what happens is, that *the alveolar bone follows the deformity of the basal bone of the mandible.* It is perhaps less obvious to know exactly why the maxillary alveolus should follow suit also

and *manifest in the severe cases a marked maxillary alveolar deformity*. In all cases the molar teeth are in some form of occlusion; the anterior maxillary teeth, however, may project anterior to their opposite number in the mandible. Whilst the deformity can play a large part it must be remembered that this condylar arrest is superimposed upon a variety of skeletal genetic types. In examining these cases this must of course be carefully borne in mind. There is a great adaptability—for want of a better term—as far as occlusion is

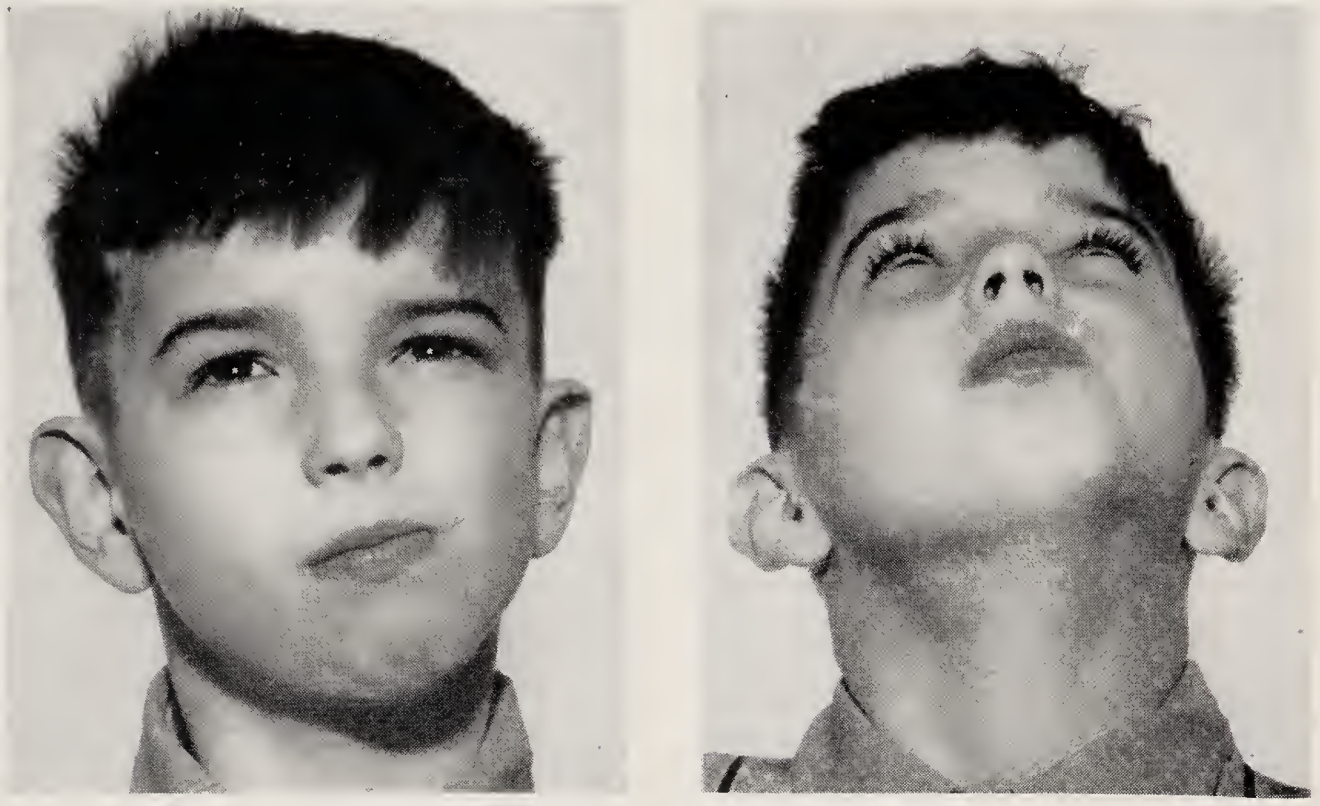

Fig. 5.—The condylar arrest of growth on the left side demonstrates the typical deviation of the chin.

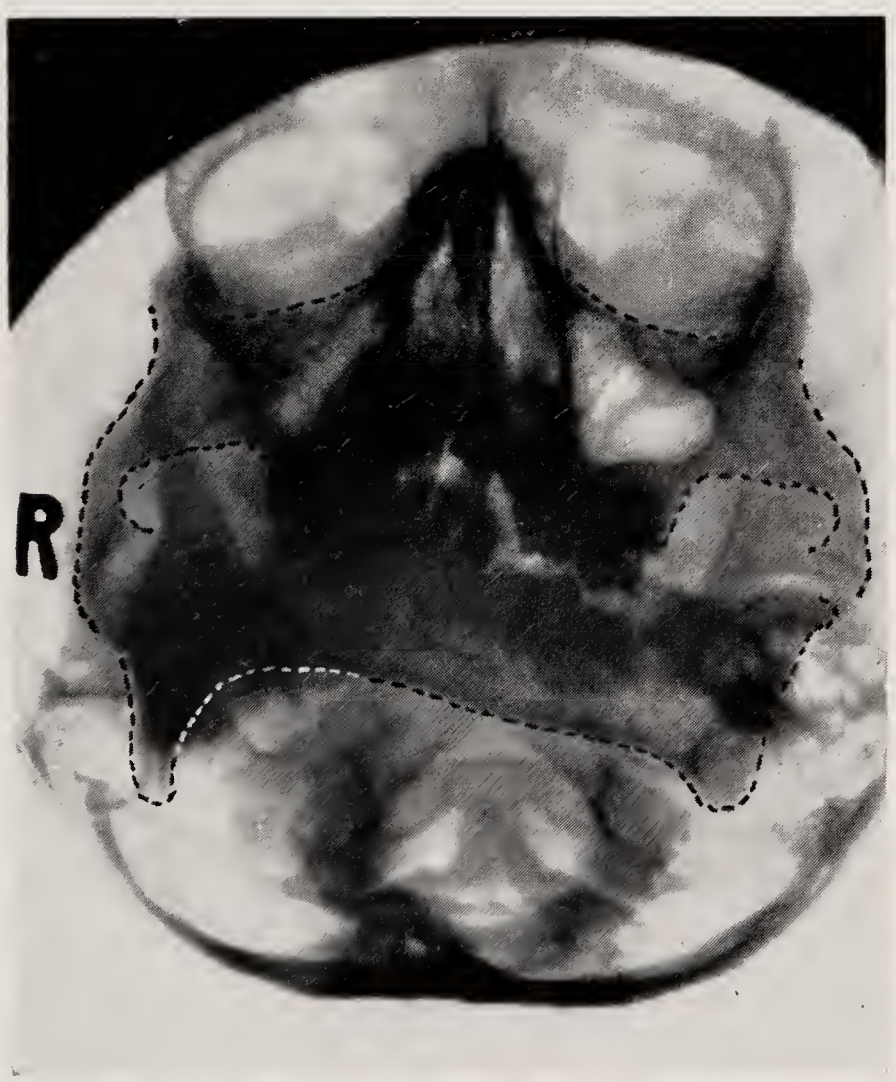

Fig. 6.—The occipito-mental radiograph shows the changes in the maxilla secondary to a primary lesion of the right condylar growth centre.

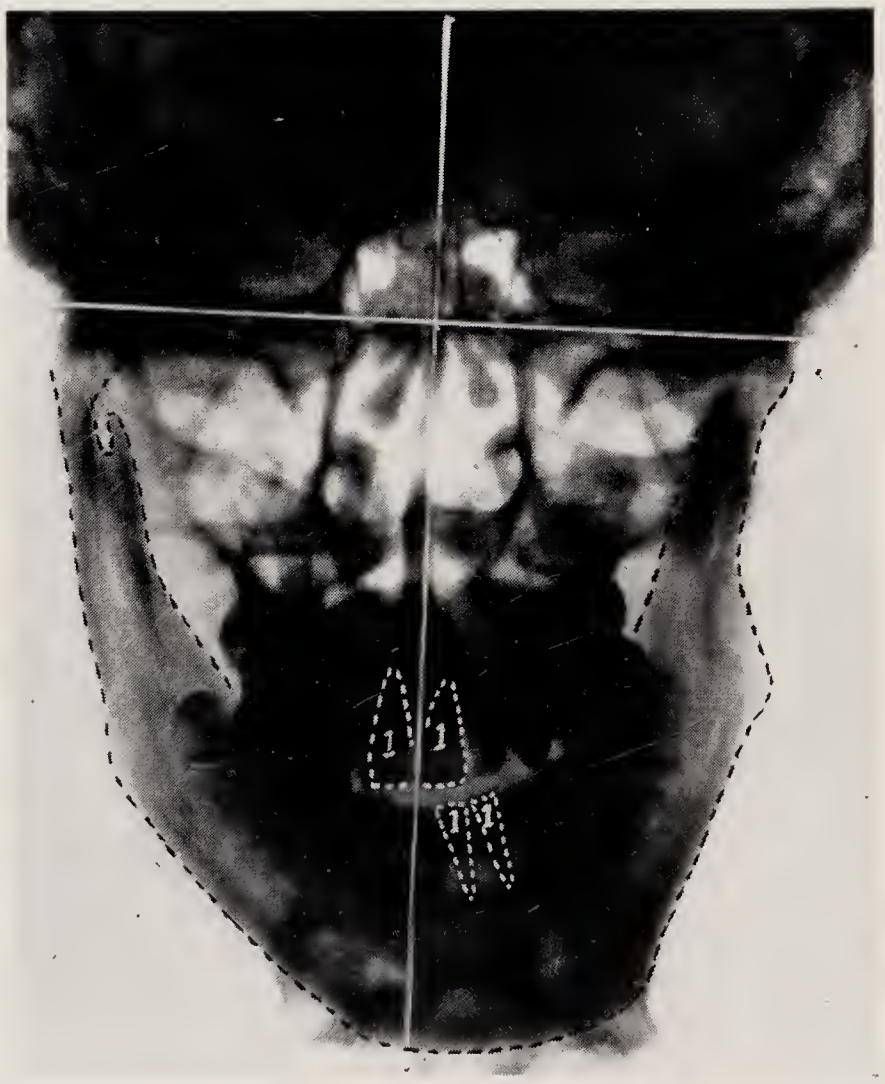

Fig. 7.—It will be noted in this postero-anterior view of the mandible that the apices of the lower incisors are displaced to the left. This side has suffered some damage to the condylar growth centre.

concerned, but only up to a certain age after which accommodation does not occur. My own feeling—though I must say without as careful examination of detail as I should like—is that after the age of 9 years the chances of adaption become very much diminished. At this age it would appear that the dentition has become stabilized. I shall refer to this point later. In skeletal Class III cases we are all familiar with the "late growth spurts". In my series I have had two such cases and both have resulted in cross bites. In other words there have only been minor adaptions of the teeth to facilitate the occlusion; the maxillary alveolus has not responded as earlier in life. It might be argued that the mandibular growth in these cases is directed in the wrong direction and therefore receives no help from the maxilla. This we shall discuss further in a subsequent paragraph.

4. The Secondary Changes in the Maxilla.—I have said that in all cases the molar teeth are in some form of occlusion; the arrest in condylar development must therefore imply *a corresponding arrest in the maxillary alveolus or maxilla itself.*

There is no doubt with regard to the former; of the latter it would appear in the severer cases that there is a difference in the levels of the infra-orbital margins. Dr. Spalding Smith and I have been keen to demonstrate this point in these and other cases. He and I have examined these cases and have come to the conclusion that there is a definite change in the maxilla itself.

It can be seen from *Fig.* 6 that there appear to be obvious changes in the maxilla. We shall be writing shortly on this subject giving a more detailed account and including many other lesions. Scott (1953) has recently stated that skulls showing abnormal growth illustrate the developmental independence of various regions of the skull. This is indeed very true and whatever the primary abnormality it is equally true to say that the compensation for such a defect can be surprising.

5. The Secondary Changes in the Chin.—The bearing of condylar growth upon the formation of the chin is well seen in the bilateral cases of condylar arrest.

The chin of *Homo sapiens* has attracted attention in fields of dentistry, since it is listed as one of his main characteristics. In studying the cases from this angle one rather peculiar observation became apparent. The apices of the anterior mandibular teeth in some of the cases seemed to be literally pushed towards the under-developed side which was lacking in condylar growth, the crowns apparently maintaining their relationship with the upper teeth (*Fig.* 7). Friel's (1945, 1949) work and interest in the migration of teeth is well known and I am sorry he is not here to join in the discussion. It would seem that this apical movement is something different to Friel's and Brash's work. The apical movement occurs at a later phase and it is dependent in some way upon condylar growth. The greater the forward condylar growth the greater the inclination of the apices. I observed in one case that the crown contact was not necessary —a case with a missing incisor demonstrated the change equally well. I studied some cases of condylar hyperplasia and noted that a similar change was evident.

In the bilateral condylar arrests we have the retroposed apices and in the bilateral Class III the apices are well forward. *There is no doubt that some relationship exists between the condylar growth and apices.* This and other reasons make me believe Scott (1955) is correct in attaching little importance to the "apical base". Salzman (1943) has mentioned the work of Walkoff who thought that the basal bone accounted for the prominence of the chin. Many workers have been insistent upon the fact that there is no appositional bone growth around the chin. If we turn our attention to Cook (1933), reporting the work of Bolk, who thought that as opposed to our nearest relatives, there was a slowing down of the process in the change from the deciduous to the permanent dentition. In the apes we had a more even and rapid change, in man there is a delay and particularly with the eruption of the second and third molars. During this period it is thought that the basal bone forms the chin while the occlusion of the teeth remains fairly stationary. Elliott Smith (1932) has also written on this subject and he thought

that the development of the brain might be an explanation. This problem will require further work before dogmatic statements can be made. Before leaving this particular point we ought to bear in mind the work of Symons (1953) and a statement by Sicher (1952) in which he states that the changes in the condylar angle are caused by a change in the direction of proliferation of the condylar cartilage. In the early years the maximum growth is forwards while later the change tends to a more downward growth. This is very important and I am sure will lead to a lot of further work. This means that the direction of growth can be influenced and is in fact in certain cases markedly changed.

6. Secondary Changes in the Angle of the Mandible.—Once again I must agree with Rushton (1948) in condemning those who still believe that there is a growth centre at the angle. The growth of bone at the angle is that of appositional bone and nothing more or less. I think Wilson Charles (1934) gives the best explanations of this bone growth when he says that the resultant downward condylar growth as it were pulls the muscle up over the ramus. *This notch in front of the angle is simply caused by the lack of downward growth and the apparent heaping up of the muscle appositional bone.* Its extent is dependent upon the extent of the condylar arrest and the already determined muscle size. In other words a condylar arrest appearing in a well-developed individual will account for a large notch.

7. Mandibular Contour.—I think we are all agreed that minor adjustments occur and that there is no extensive resorption of the anterior surface of the ramus.

Acknowledgements.—I must express my sincere thanks to Professor T. Pomfret Kilner, Mr. R. P. Osborne, and Mr. J. P. Reidy; without their kind help it would have been impossible to collect this number of cases.

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DISCUSSION

Mr. Walther said it must be obvious to everyone present what an enormous amount of time and hard work Mr. Greer Walker had put into his paper, which had been extremely enjoyable. Having been invited down to Stoke Mandeville he had been amazed at the amount of material which Mr. Greer Walker had managed to collect, of which he had just shown only a very small fraction. The gross cases were very interesting from the point of view that the alteration in the growth pattern might provide some clues through the secondary changes which took place. It would be interesting to see a serial growth study take place, using X rays, study models, and careful clinical comparisons which could be controlled from a group with a normal cross-section of children. He felt that the prognosis must depend very largely on the individual's skeletal pattern and muscle behaviour, upon which the deformity had been superimposed. It was certainly very important in the prognosis of a cleft palate case, and was very difficult to assess.

The paper was so full of interest that there was only time to mention one or two points. It was interesting how the age at which the damage occurred affected the direction of growth, and in that connexion a great deal could be learned from a serial study. Secondly, could the author give a reason for the observation that as the opposite side grew the apices of the teeth on that side were further forward than the crowns? Lastly the secondary development of the maxilla was an exceedingly valuable observation, especially as it occurred both in congenital and acquired cases, and he wondered whether it occurred more often than was generally realized. It seemed that it could not be due to infection or trauma.

With regard to the points for superimposition, Mr. Greer Walker had shown how very careful one had to be in choosing those points and how difficult it was to interpret them. Had he any suggestions to offer of more stable points which could be used?

Mr. J. H. Hovell said the paper under discussion was of very great importance from the point of view of orthodontic aetiology. In this country we were getting rather familiar with the soft-tissue morphology outlook upon malocclusion, but there was a big body of opinion that those who believed in the effect of soft-tissue morphology on the position of the dental arches were in fact talking about an association and not a causative condition. He believed that the cases so ably shown by Mr. Greer Walker demonstrated a very definite causal relationship between soft-tissue morphology and the dental arch relationship and the position of the crowns of the teeth. He felt quite sure that in those cases the soft tissues, which were in the large majority normal, endeavoured—and in many cases succeeded perfectly—in moving the dental arches into a completely normal relationship, even though the basal bone itself was grossly deformed. That was the complete answer to those critics who maintained that they were merely pointing out a relationship which was not in fact causal, and from the orthodontic point of view at least that was the most important point that Mr. Greer Walker had brought out. He had also shown not only the influence of soft tissues upon the dental arches but upon the bone itself.

Mr. Hovell said he had thought a lot about the condylar dysplasias and he wondered whether Mr. Greer Walker had ever considered the possibility of changing the skeletal pattern by interference with condylar development at the appropriate age, for instance in Class III cases. He had gone into the matter intensively with the radiotherapists as to the possibility of stopping condylar growth but eventually abandoned it because of the possible late malignant change due to radiation, but it would be interesting to hear whether Mr. Greer Walker had given the method any thought as a possible treatment for malocclusion.

Mr. Glass thanked the author for letting a breath of fresh air into the orthodontic world. Mr. Greer Walker was obviously a keen observer of his patients and did not rely on what might be termed "wishful tracing" of his lines. The first and most important thing was that orthodontists were now emerging from the straight lines of growth: it would look very nice if everything grew at right angles to the various sutures but the fact remained that current research tended to disprove that, and the picture on the board, although a little exaggerated, was on the right lines.

A point which he wished to ask the author was about the orbits in which there was no malar bone. The orbit was really a cavity surrounded by suture bones which expanded because of the orbit, and in the cases in which he had been interested the orbit was definitely very deficient on the side in which there was no stimulus to growth. The same applied to the cranium, which was a cavity, and the sutures did not grow unless they were stimulated to grow to any great extent. In the cases which Mr. Greer Walker had handled it would be interesting to know whether the malar bone was replaced.

The author had spoken of the treatment of ankylosis and it would be interesting to hear his views on the treatment of bilateral ankylosis in which it would be impossible to get a spatula into the mouth, although Mr. Greer Walker had somehow managed to get models. In those cases would it be better to liberate the entire mandible and remove the ramus into whatever position one considered desirable? Would that give one more notch than the hideous results which one saw from the inactivity due to the ankylosis?

Mr. F. E. Hopper expressed the view that in the description of the notch the emphasis had been on the wrong thing. The emphasis should be on the bony spike behind the notch, and when the last spcaker said that with the ankylosis the patient suffered from lack of function he believed that as a rule the contrary was the case and the muscles seemed to be hyperactive. He had seen some cases where there had been a reduction in the size of the bony spur after operations to restore movement.

Mr. J. Campbell, referring to immobilization in the treatment of condylar fracture, asked Mr. Greer Walker to expand on it from the point of view of the period of immobility and whether or not it was carried out with or without reduction of the actual displacement of the condyle head.

Mr. Hamish Anderson asked whether the notching was only associated with disturbance to the condyle of a very young person and that after the age of 8 it was not so marked and at about 13 there was no notching at all? Also, could one use that notching as a guide as to whether one should endeavour to make an improvement in the occlusion? In other words if the notching was very pronounced that would be a definite case where one would not attempt it.

The Chairman (*Mr. Ballard*) said although Mr. Greer Walker would probably wish, in order that he could have an argument, that he was producing something with whieh they were not in agreement, in fact he believed that if they got together and discussed their lines of thought it would be found, in the end, that they were not so very far apart.

Mr. D. Greer Walker, in reply, thanked Mr. Walther for his kind remarks. With regard to the apical movement he (Mr. Greer Walker) unfortunately did not know the answer: this observation only became more apparent towards the end of the preparation of this paper—some ten days ago. The Chairman, Mr. Ballard, had made certain observations which led him to believe that they were really talking the same language but in a slightly different dialect. (*Acclamation.*)

When one observed some Class III cases with the apices placed anteriorly one was up against the perennial problem of what was relative to what, and that was the difficulty which arose so often. He had thought this was an important observation which he ought to make and it was the sort of thing one really wanted to think about before trying to answer it any further.

Regarding the points for superimposition, that of course was another tremendous problem. His interest at the moment was in the maxilla and whether one should measure maxillary deformities in that way he did not know. He only tried to do what the anatomists did, and put one on top of the other.

Mr. Hovell had talked about stopping condylar growth: while being in no way an expert on that subject the point seemed to be that one could not be sure of the end result. If it was possible to say at the age of 6 "This mandible is going to be here", it could probably be justified, but all plastic surgeons seemed to agree that it was the one joint which frightened everybody.

Mr. Glass had talked about treatment but Mr. Greer Walker said what he had tried to amplify were that the malar bone was completely absent, and the attempts to form an orbit by the surrounding bones. With regard to ankylosis, following upon the present paper and with the assistance of Mr. Osborne he had almost completed a paper on the treatment of those cases. Referring specifically to the question of bilateral ankylosis, it all depended upon how bad the deformity was and how good the function.

He had quite glibly commented on the treatment of fractures but on looking up some notes he had found that he had put on some wires for one of the children and the wires came off, and then he had put on some cap splints and they came off. It was an awful problem but he believed one should make some attempt at fixing the jaw and he would have no hesitation in immobilizing, because he felt if there was damage then one might get ankylosis.

With regard to Mr. Hamish Anderson's questions, Mr. Greer Walker said he could not give an expert opinion on what orthodontic treatment should be done, but he thought far too much importance was attached to that particular point. It was indicative of condylar development and also what the child was going to be. In other words with a typical Class II case one would get very big muscles but with the typical Class III cases, which were exceedingly thin and long, it did not seem the same thing at all.

EARLY RECOGNITION OF SOME AETIOLOGICAL FACTORS IN TEMPOROMANDIBULAR JOINT DISORDERS

By **H. E. WILSON**, L.D.S. (Q.U.B.), D.Orth. (Eng.), D.D.O. (Glas.)

My interest in disorders of the mandibular joint was for some time casual, but heightened after a number of these cases had been referred for orthodontic opinion and treatment. As a result, I became more aware of the association between malocclusion and the disordered joint. It pleased me when my early cases were successful, the correction of the malocclusion resulting in a marked improvement in the joint symptoms. The majority of these cases were easily diagnosed and easily treated, most of them being cross-bites.

As time passed, more puzzling cases came my way, also fewer startling successes. Nevertheless, most cases improved following orthodontic treatment and, as Dr. Campbell (1954) pointed out, I have "learnt even more from the occlusal breakdown of patients who have never known orthodontic care" and I "get along perfectly well with a good pair of eyes and palpating finger-tips". The only other aids are joint X rays and an anatomical articulator.

It is assumed that when the condyle is displaced distally the symptoms arise as a result of the pressure on the posterior fibrous part of the disk, termed by Rees (1954) the bilaminar part, and said to be well supplied with blood-vessels and nerves (Sicher, 1948; Hankey, 1954). I have no intention of reviewing the literature on the subject and its many aspects; it is so voluminous and little of it deals with the orthodontic approach (Schreiber, 1954).

It became obvious early that the direction of mandibular displacement was significant if orthodontic treatment was to be planned and successfully executed. With this in mind I classified the cases as: (1) Over-opening; (2) Over-closure; (3) Lateral displacement; (4) Backward displacement (Wilson, 1952, 1953). To each may be added the subdivision of "unilateral" or "bilateral", and in my opinion these will include all the mandibular displacements associated with joint disorders. It is based on Thompson's (1946) concept of the resting position of the mandible and the freeway space and his belief that the condyle rotates in normal cases when the mandible moves from the resting to the closed position. All displacements refer to the movement of the mandible from the resting position.

1. Over-opening.—Cases of over-opening are rarely referred to the orthodontic clinic. The symptoms are seldom severe and consist chiefly of a clicking either during the opening or closing movement. The patient often does it voluntarily. Reasons put forward for the cause of the clicking are numerous, but none has definitely been established. Indeed there may be almost as many reasons as there are "clicks". It occurs initially with yawning, singing, following extraction, or, as in one case, by biting hard on an object on the molar teeth, or with anything which displaces the condyle forward over the eminentia, this being referred to as subluxation. Treatment is limitation of movement and, since it so often is repeated voluntarily, demands the co-operation of the patient. When the symptoms are more severe, intermaxillary wiring may be used.

I have noticed that some cases of over-opening are associated with a pre-normal occlusion or an obtuse-angled mandible. It would appear that when the mandible is opened the average distance between the incisors in Class III types is less than the normal incisal relationship, so the individual opens a little more to produce an opening wide enough for the introduction of food; in so doing the condyles are moved over the eminentia. In the obtuse-angled mandible it appears to be a feature associated with the skeletal type.

Given at the Newcastle upon Tyne meeting held on May 11, 1956.

There may be unilateral subluxation of the condylar head; if this is so, it is generally confined to the same side each time, but there may be a bilateral subluxation, in which case one side slips forward followed by the other, the chin point moving to one side then the other. Simultaneous subluxation of the two joints is less common in my experience.

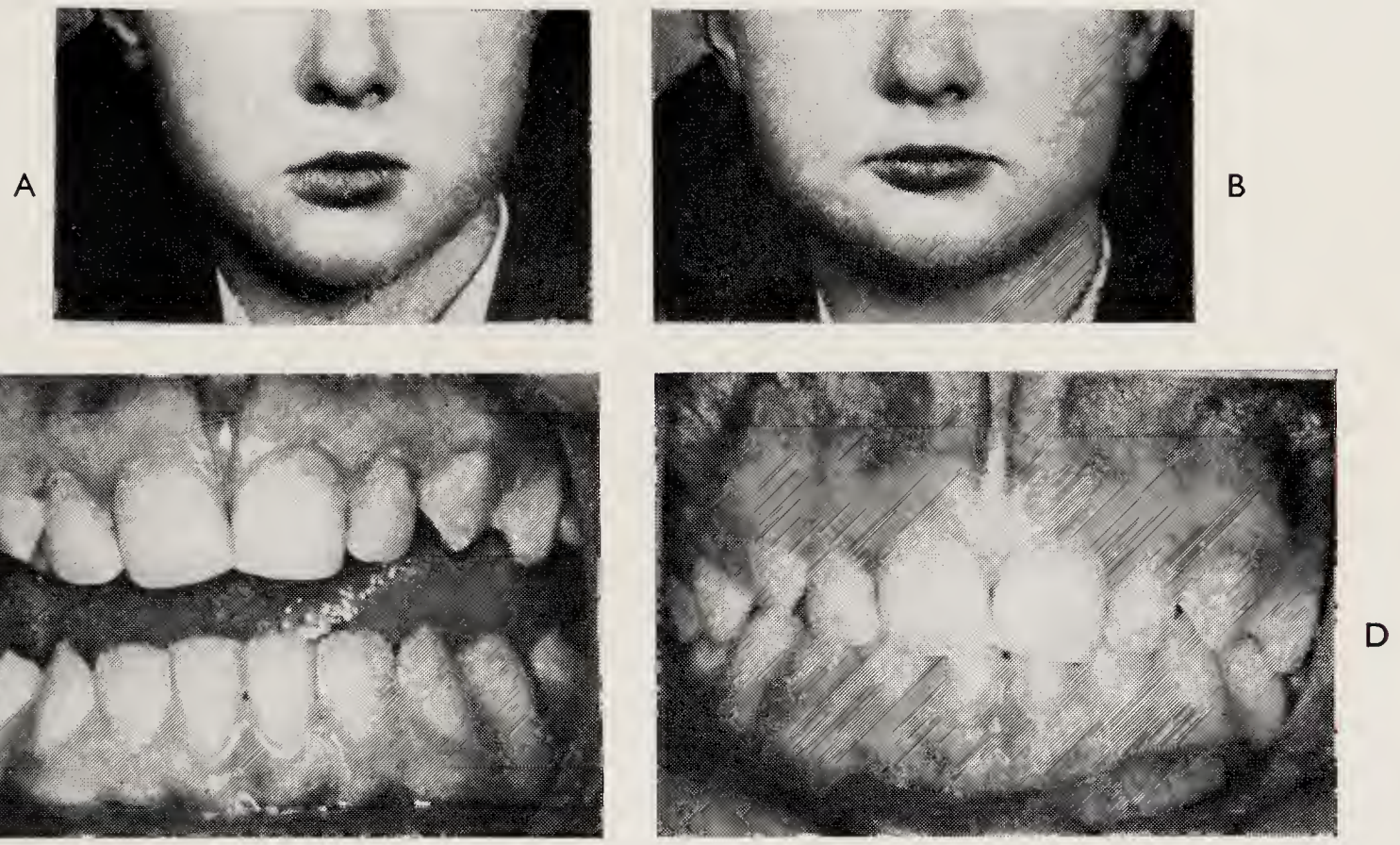
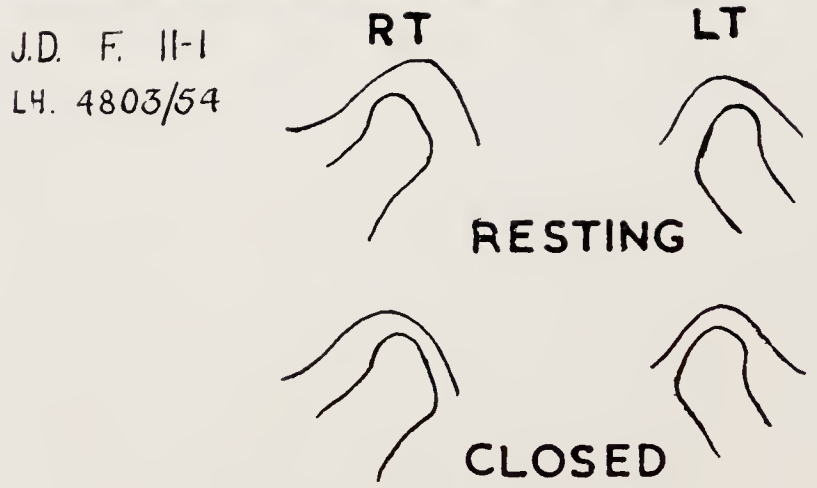


Fig. 1.—Showing resting (A, C) and closed (B, D) positions. There is overclosure and distal displacement of condyles.

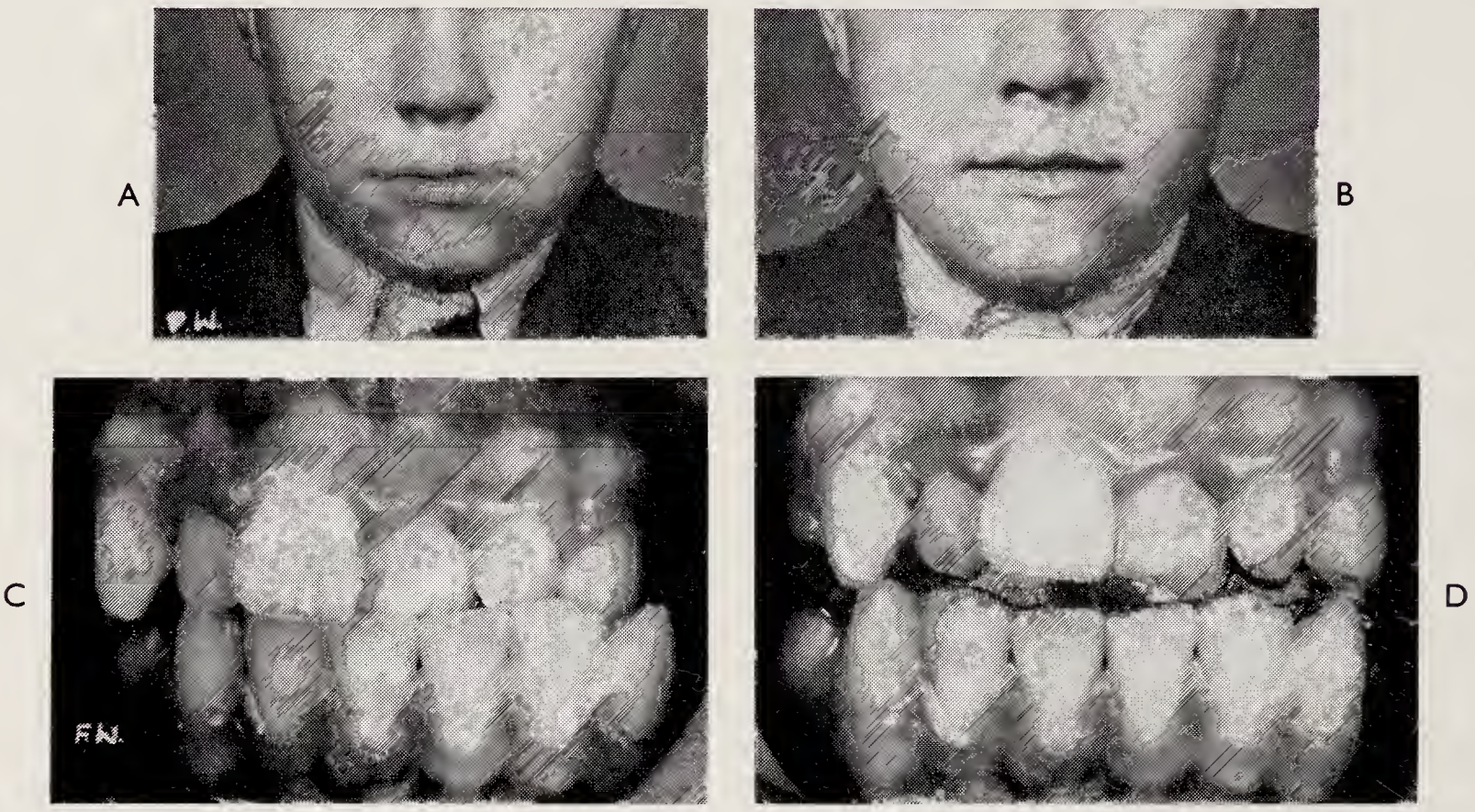
Severe pain rarely appears unless associated with some other form of displacement, for example, in the mutilated case with lateral displacement or gross over-closure.

In children over-opening can easily be missed. The child patient is rarely asked to open as widely as possible with the intention of observing the condylar movement. It may be recognized when taking impressions or fitting appliances provided one is alert to the movements of the mandible. When recognized, correction is not difficult. It is easy to convince the patient that it is to his or her advantage to resist clicking the jaws, which is often the only symptom. I have found that after six to nine months the young patient is unable to over-open voluntarily as before, provided the skeletal pattern is favourable. In the obtuse-angled mandible with short ramus, over-opening may be almost impossible to control and some of these types appear to have a small condyle in a small, comparatively deep, fossa.



2. Over-closure.—In over-closure of the mandible the condyle is thrust back against the fibrous posterior part of the disk. The clinical picture is often poorly-designed dentures or grossly-mutilated dental arches. Accordingly, the over-closure, and consequently the symptoms, may be unilateral or bilateral. Treatment is bite rehabilitation by prosthetic appliances, or bite-opening appliances to reconstitute the vertical height and prevent the distal displacement of the condyles. Prognosis is generally good, the symptoms being alleviated within a day or two.

Over-closure occurs in cases of large freeway space (*Fig.* 1), and in these the excessive movement may be prevented by bite-raising appliances or onlays. Early recognition of this type is not difficult. In my opinion there are two reasons for large freeway space: (*a*) lack of alveolar growth associated with a general condition, or with a local factor such as partial or complete anodontia, which cannot be corrected; (*b*) behaviour and size of tongue; if the tongue normally rests between the upper and lower teeth it will prevent their full eruption. It is known that there can be an association between an anterior tongue thrust and an anterior open-bite and that when the tongue thrust is corrected the teeth come together. It is possible for a similar association to exist between the cheek teeth and the tongue. There is no method of determining whether or not a tongue is large in relation to the dental arches and jaws. At times, when it rests between the upper and lower teeth, it appears large, while at other times its size seems normal and its position due to tongue behaviour. In the former type the prognosis is not good; in the latter it is better but doubtful. Correction of the freeway space will correct the mandibular and condylar displacement.



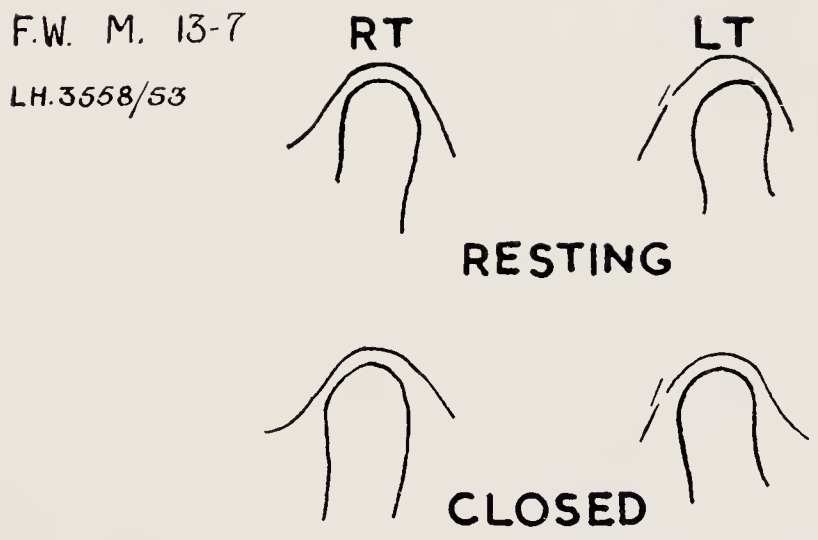


Fig. 2.—Shows the centric occlusal (B, D) and occlusal (A, C) positions with cross-bite and mandibular displacement to the left which result in a distal displacement of the left condyle, as shown in X-ray tracing.

Diagnosis of the resting position and large freeway space is not difficult when the patient has upper and lower anterior teeth. My method is to sit in front of the patient who is asked to sit upright in the dental chair and we carry on a conversation. I notice the position to which the lower teeth return during speech and this gives the resting position; then the occlusal position is noted and from these the freeway space is measured. Other diagnostic aids are speech, which may give the first clue, and the impression of the teeth on the tongue. Speech may be "thick", which I tend to associate with the large tongue and the lateral sigmatism which suggests tongue behaviour.

Treatment for the tongue behaviour consists of exercises by a speech therapist and a form of internal oral screen, for example, a monobloc. Where there has been some lateral collapse or narrowing of the arches in the premolar region associated with tongue behaviour, the arch may be expanded and in the improved environment the tongue behaviour improves.

clinically, caused by the position of one or two teeth; treatment depends on the individual and may be orthodontic (with an expansion plate) or occlusal grinding.

These conditions are easily recognized early and their treatment is generally simple and straightforward. In the deciduous dentition, grinding of the offending cusp may be all that

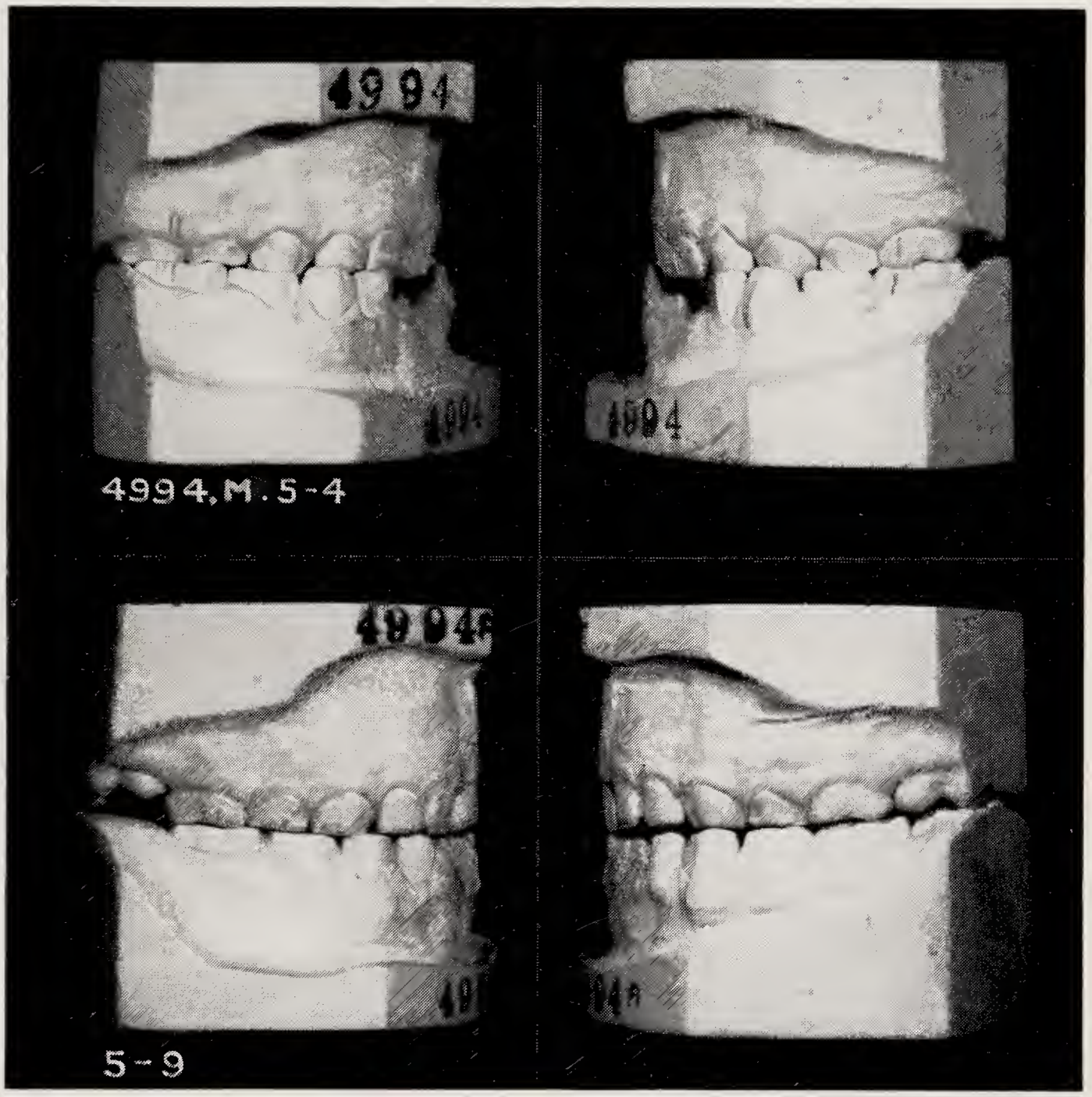


Fig. 3.—Shows cross-bite, with lateral displacement corrected by grinding, only in five months.

3. Lateral Displacement.—This displacement is probably the most easily diagnosed. The symptoms are usually unilateral and on the side to which the mandible moves. One condyle is moved distally against the posterior part of the disk while the other is stationary or moves forward (*Fig.* 2). In established cases expansion may be attempted, or grinding to allow centric occlusion. The prognosis is good and orthodontic treatment usually produces a stable occlusion. There may be mild cases of lateral displacement, difficult to observe

is required, or, at the most, simple expansion. Grinding of permanent teeth is not indicated at this age (*Fig.* 3). Cross-bite due to a narrow upper arch resulting from a sucking habit must be treated initially by correction of the habit.

4. Backward Displacement.—This displacement is probably the most difficult to diagnose as it is almost impossible to observe clinically. It is often associated with Class II, Division 2 type of occlusion. The mandible is thrust backwards carrying the condyle against the posterior part of the disk, producing severe

symptoms which are usually bilateral but may be unilateral (*Fig.* 4). The most useful guide to diagnosis is the attrition of the teeth, which, if carefully noted, will assist in building the picture of the functional occlusion. Attrition on the incisors is not difficult to observe (Weinberg, 1956), but on other teeth it can

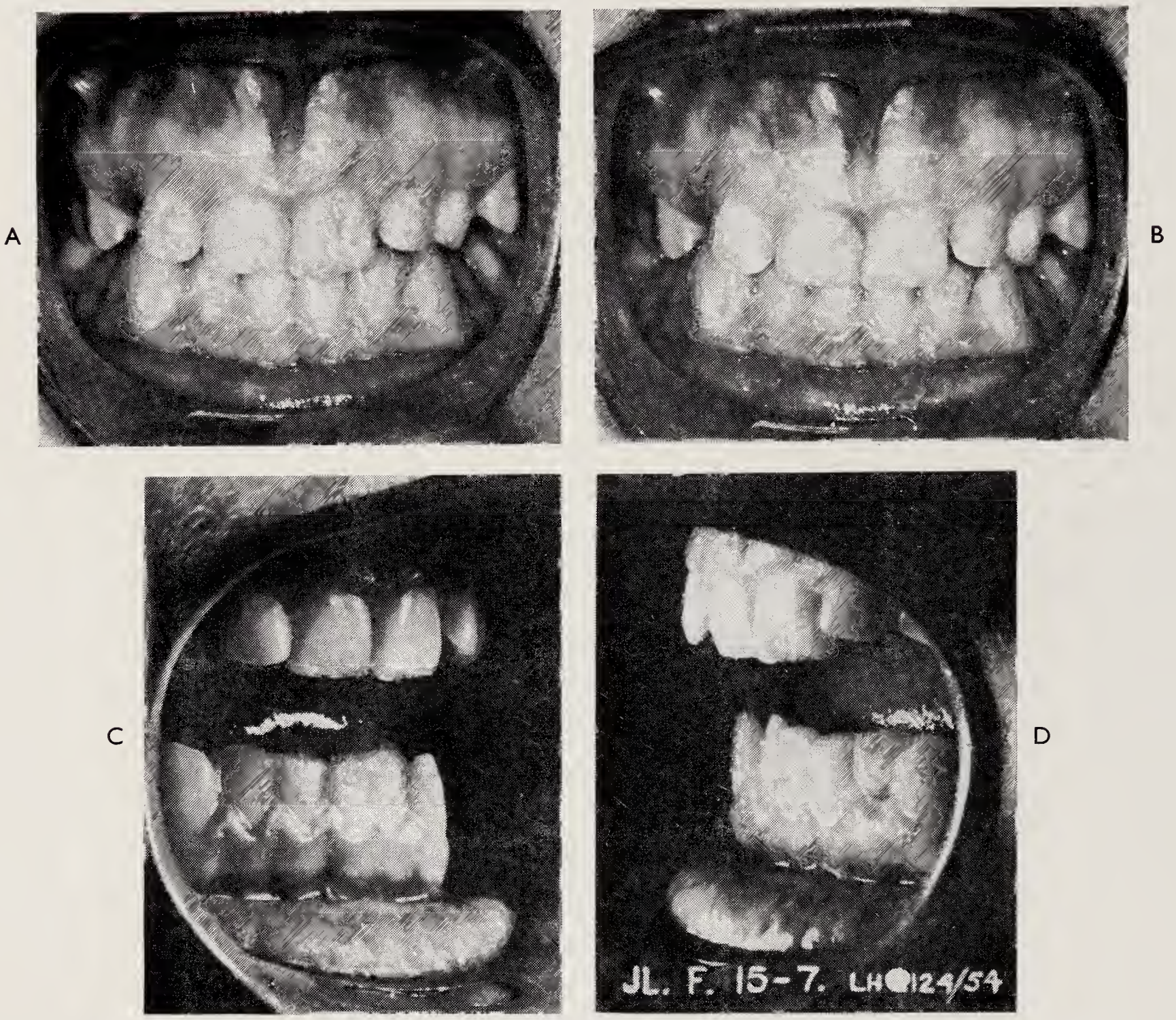


Fig. 4.—Showing teeth in initial contact (A) and in occlusion (B). The movement from one position to the other was sharp and quick. C, D show attrition on labial aspect of $\overline{1|1}$. Radiographs confirmed distal displacement of the condyles following the backward displacement of the mandible.

be easily overlooked. Canines are often involved when they tilt distally and lingually, occluding in such a way as to produce the backward thrust. Occasionally, a tilted molar or molars may be responsible. Radiographs of the joints taken in the resting and closed positions are of some assistance.

Treatment may be by bite-raising appliance or grinding of the offending cusps. Orthodontic treatment usually consists of correction of deep overbite and arch relationship. In some mutilated cases it is necessary to correct the incisal relationship with orthodontic appliances to retain the corrected arch and support the occlusion.

Early recognition of distal displacement is confined chiefly to deep overbite cases. Removable appliances with inclined planes are remarkably successful with, or without, extraction of upper premolars. If this treatment fails, which it rarely does, the case is re-assessed.

Schwartz (1956) has shown that it is possible for people with normal occlusion to retrude the mandible and so compress the disk voluntarily.

The interesting question arises why some cases with a traumatic bite will produce a

parodontal condition while others produce joint symptoms. A deciding factor may be the direction of force applied to the tooth; if it is in a vertical direction and along the long axis of the tooth, it will displace the mandible, but if the force is applied horizontally it will

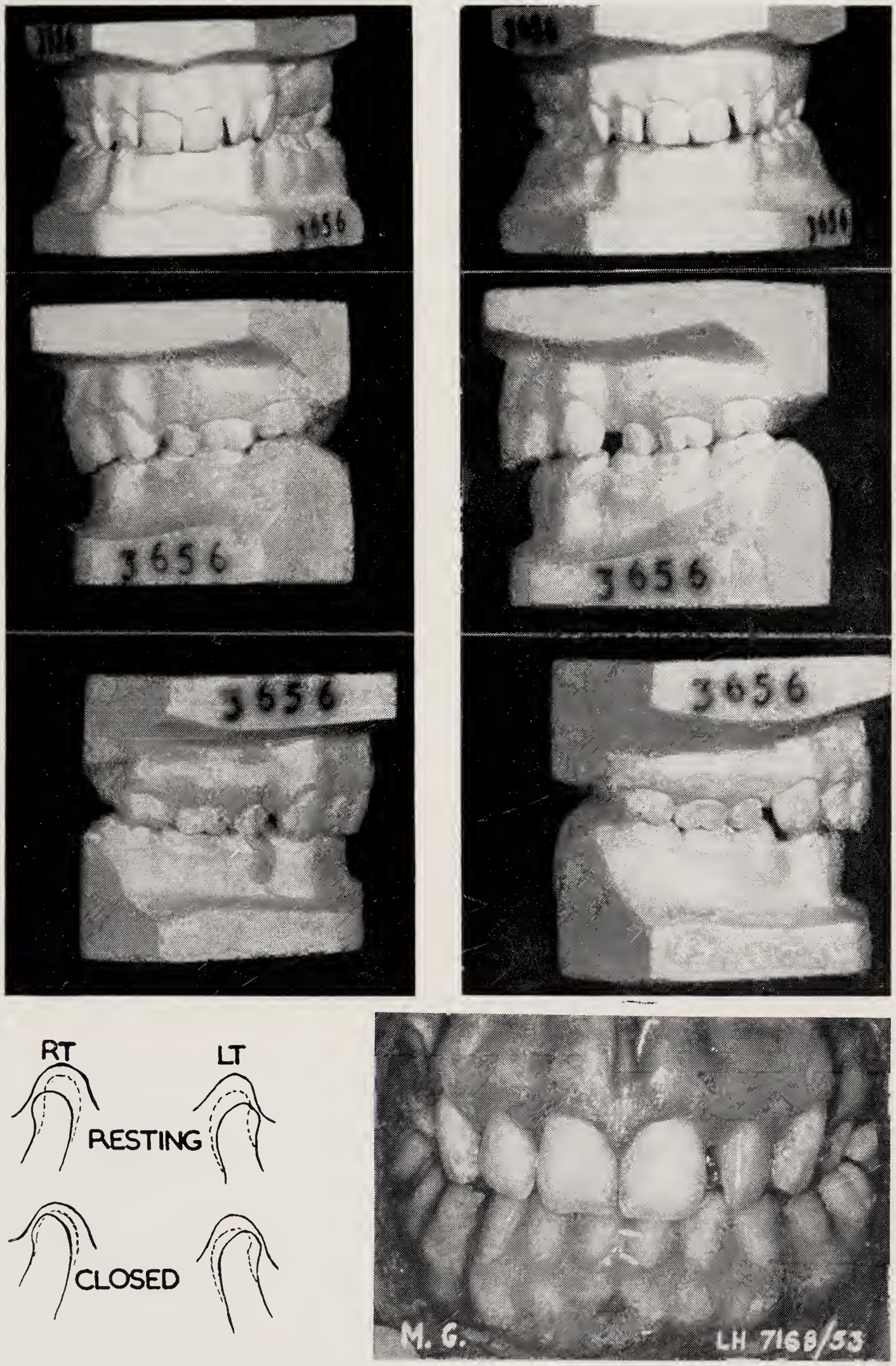
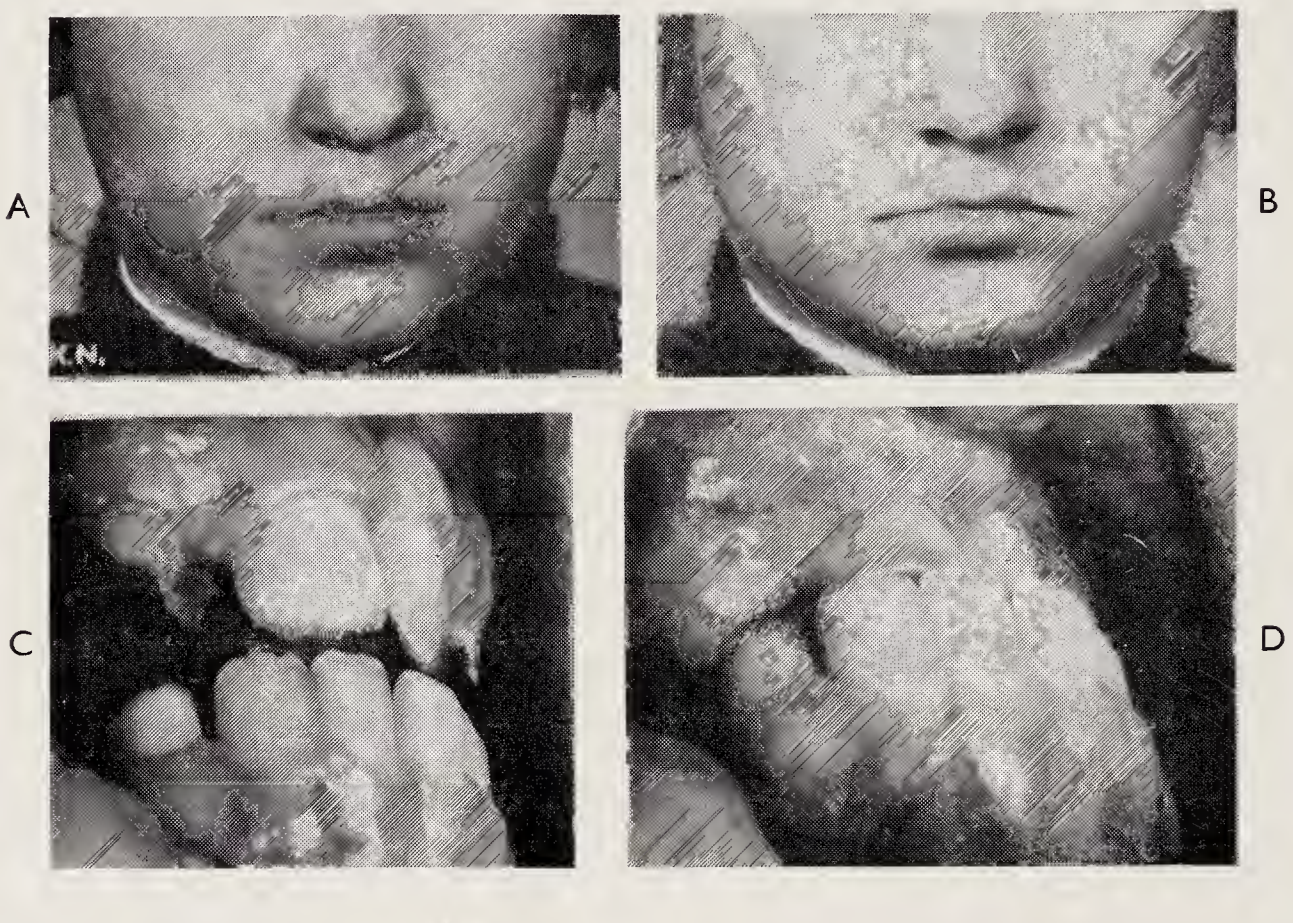


Fig. 5.—Extraction of four first premolars for orthodontic treatment resulted in deep overbite and backward mandibular displacement with joint symptoms. Treated with a removable appliance. Models show progress of treatment with change in arch relationship and correction of deep overbite. Joint tracings show the position of the condyles in the resting and closed positions before (broken line) and after (continuous line) treatment. Intra-oral photograph shows the result one year later.

tend to loosen the tooth. The support of the proximal teeth may be sufficient to resist the breakdown of the parodontal tissues which might otherwise occur if the tooth is isolated. In the case of canines, the morphology and size of the tooth may determine the result and in addition it comes under the influence of the strong muscular modiolus of the cheek which



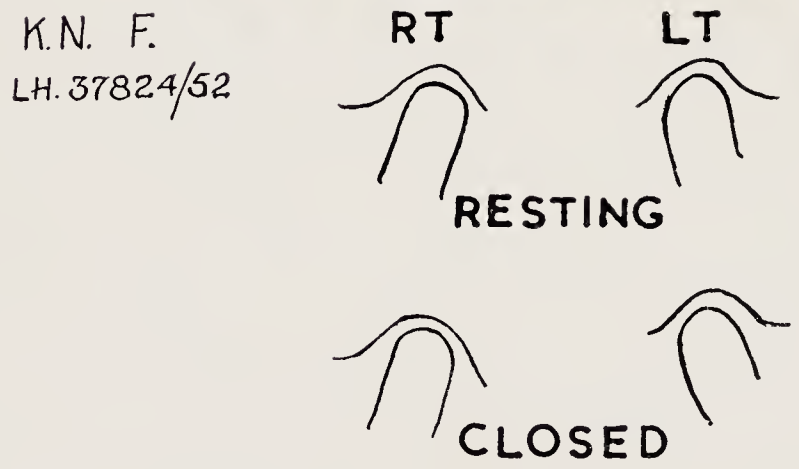


Fig. 6.—Large freeway space and over-closure; condylar displacement is prevented by the postural prenormal occlusion. A, C, show resting position; B, D, the occlusal. Joint tracings show no change in joint space.

may prevent its labial displacement. Where there is a premature and sliding contact involving this tooth the result is a mandibular displacement. Rarely does it produce pathology of the parodontal tissues.

Having learned something of occlusal breakdown in adults and become familiar with the type of occlusion which is commonly associated with joint disorders, one automatically applies the knowledge gained to the orthodontic patient and endeavours to correct those malocclusions likely to produce joint symptoms later, and what is probably more important, to avoid producing such occlusion with orthodontic treatment. It occasionally happens that in correcting a cross-bite a lateral displacement is produced. For example, a unilateral cross-bite, without mandibular displacement, corrected by symmetrical expansion of the upper arch may produce a lateral displacement of the mandible. Extraction of upper first premolars in some Class II cases and four first premolars in Class I cases, and retraction of the incisors, can produce a deep overbite and a distal tilting of the canines which will result in a backward displacement (*Fig.* 5). This may be an argument in favour of extracting lower second premolars rather than lower first premolars in cases of bimaxillary crowding because it produces less anterior collapse. Backward displacement can also be produced by late extraction of lower first molars, allowing the second molars to tilt excessively, and in Class III occlusions where the lower incisors are retroclined and the upper incisors proclined.

The orthodontist may consider being satisfied with producing an edge-to-edge bite where

possible, rather than an overbite, in some prenormal cases. It is an excellent procedure to see treated permanent dentition cases six months after appliances have been removed and to do selective grinding where there is premature contact or slight mandibular displacement.

No mention is made of the forward mandibular displacement or the postural Class III. In my experience such an occlusion does not produce trauma within the joint unless it is associated with some other form of mandibular displacement. Even so, the forward bite can cancel out the distal displacement produced by an over-closure, as in the case illustrated (*Fig.* 6). I may be wrong and, as suggested by Dr. Campbell (1954), there is a nipping of the disk between the condyle and the eminentia in some of these cases.

It is not suggested that all mandibular displacements eventually produce joint conditions. We can only do what we consider best for the patient and, if a mandibular displacement is unavoidable, hope that the other factors do not appear to produce the joint symptoms.

What are these other factors? Schwartz (1955) lists them as:—

1. Predisposing: consisting of constitutional (physiological) temperamental (psychological).
2. Contributing: occlusal abnormalities.
3. Precipitating: sudden or continuous stretch (yawn, wide bite, long dental operation); sudden or extensive changes in proprioception (occlusal alteration through restoration or selective grinding).
4. Aggravating: alarming diagnoses or physiological or psychological traumatic treatment.

The separation of the known factors in this manner has some merit, but I do not completely agree with it. The important or primary factor is the mandibular displacement which may be predisposing at one time and contributing at another. There are many cases where there was no precipitating factor, such as a sudden blow, and the symptoms have a more gradual onset.

It must be accepted that temperament and the psychological state are factors (Moulton, 1955). The much higher percentage of females presenting with the symptoms confirms the temperament. Symptoms appear during periods of "stress" which produce the psychological state, which in turn produces the muscular tension. Thus the teeth are held in occlusion, and the joint, instead of receiving a mild repetitive traumatic force which it can withstand, may receive an almost continuous one. Lewis (1942) has shown that pain in muscle may resemble pain from the joint, and this may account for some of the pain symptoms. In those cases where there is no marked mandibular displacement, muscle tension may partly be the answer. Cases have been successfully treated by instructing the patient to relax. The change can be surprisingly rapid, the symptoms disappearing in a few days. One case of a young man with joint symptoms will illustrate the point: he had a fair complement of teeth with good functional occlusion, except on the right lower molar region where several teeth had been lost. His father had recently died from cancer and he had the responsibility of running the small family greengrocery business and was under considerable mental stress. When assured that he had not a similar condition to his father he was greatly relieved and received instruction in relaxation. He was not seen again, but some weeks later he wrote saying he had no further symptoms and considered it a waste of time to visit the hospital again. There are people with less obvious worries who also benefit from this advice.

A cycle of factors goes to produce the joint symptoms; they include mandibular displacement, temperament, psychological state, muscle tension, trauma, and the morphology of the joint. If the cycle is broken there is relief. The most effective measure appears to be decompression of the disk where there is distal displacement of the condyle, or rest when there is over-opening.

Description of the normal mandibular and condylar movements and structure is best left to the research workers on the subject (Posselt, 1945).

I have not discussed the variety of symptoms associated with joint conditions because those

who have worked in this field have not been able to produce anything significant, nor have I discussed causes other than intrinsic or extrinsic trauma. It is obvious that these must be eliminated. Hankey (1954), in his survey of 150 cases, found 6 due to other systemic and pathological conditions, which is only 4 per cent of all cases. Almost all joint disorders, therefore, are associated with some form of mandibular displacement or trauma. Keeping this in mind, I am never satisfied with a casual examination of the functional behaviour of the oral cavity when there are joint symptoms present. What at first sight may appear to be a good occlusion may, in fact, produce a slight mandibular displacement which is sufficient to account for the symptoms. In such mild cases, joint radiographs may not be of much assistance, since the reduction in joint space may be small and within the normal range, so not easily diagnosed from radiographs. The anatomical articulator may help in studying the premature contact, but there is no easy road to diagnosis and these two techniques only supplement the clinical examination.

In conclusion, orthodontic treatment for temporomandibular joint cases can be of considerable benefit to the patient by removing the cause of the mandibular and condylar displacement. In treating these cases considerable knowledge is obtained of the type of conditions where occlusal breakdown occurs. This knowledge can be employed in treating orthodontic cases to correct or avoid the occlusal states likely to produce joint disorders later.

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DISCUSSION

Mr. J. Campbell said that one should be cautious before designating a mandible "displaced": it was probably true to say that a mandible which was swung to one side was displaced, especially if fixed asymmetrically. When the jaw slipped into the so-called "postural Class III position", it was displaced too, but he would hesitate to use the term in most of the Class II anomalies: it might appear that the jaw was pushed to the rear on a cusp-interference, but that did not mean that the condyles were pushed back too. It was a plausible theory, but proof was not yet at hand.

Mr. Wilson had shown an excellent slide depicting oblique attrition on the lower incisors, which generally suggested posterior displacement of the mandible, and it should be remembered that if the jaw is driven back, so also are its condyles, although, as mentioned, we cannot be certain. He had noticed that Mr. Wilson had carefully confined his classification of displacement to the mandible, and did not classify condylar displacement.

Nine years ago, he, in company with his orthodontic colleagues, had set up a clinic primarily to deal with facial pain, and since then had found that the temporomandibular joint was often the seat of the trouble. It is better to prevent trouble rather than to cure it. This was the real lesson to be derived from Mr. Wilson's paper.

The orthodontist had a wonderful opportunity to nip trouble in the bud.

Turning now to adults, it might be said that the treatment should be left to the prosthetist, because many of the patients were edentulous—some had lost their teeth in the natural course of events, and, of course, there were others whose teeth had been weeded out one by one, each sacrificed in the hope that it would be the particular cause. Now, although the orthodontist could do much to steer the patient away from the temporomandibular trouble, the actual treatment of pain was usually by prosthesis, and the prosthetist came into the picture at a time when the mouth was in ruins: all he could do was to shake his head sadly and then proceed to work miracles. I may say in passing that his skill is not appreciated sufficiently, not even by orthodontists.

Another argument in favour of the orthodontist taking up the treatment of actual pain is that he is more familiar with the minutiæ of functional malocclusion than any other dental specialist, and I do believe that the nature of his work has given him a finer perception.

The first *slide* depicted a simple cross-bite—the sort of thing one saw every day. This did not necessarily lead to pain, he said, as the cross-bite did not shift the jaw: it was a static malocclusion rather than a functional malocclusion.

The next *slide* was different: in this example the jaw was deflected with every bite of food. The third *slide* took the patient to more advanced years and was included to show that facial asymmetry was not an

inevitable accompaniment of pain. In cases of this order, where asymmetry had developed gradually since childhood, there was a likelihood that bone-growth made adjustment in the temporomandibular joints, so that the condyles never became deflected. Even a major occlusal disaster like the loss in childhood of a first permanent molar was readily compensated in the joint: it is true that there will be a certain amount of deflection and closure of the vertical dimension, but our radiographs show remarkably little change in the joint spaces. However, one cannot dismiss the possibility that children may suffer temporomandibular pain, but if they do, then it is usually overlooked, or dismissed as a "little touch of earache".

The fourth *slide* showed a mandible thrust forward on one side and back on the other, another form of mandibular deviation. It should be noted that the removal of all the teeth, should that step be indicated, will not always cure the deflection, nor cure the pain: indeed it may aggravate it by adding "closure of the vertical dimension" to the pre-existing deflection.

The fifth *slide* showed how a new factor could enter this story of a progressive deterioration of a cross-bite; reference is made here to the fixation of one or both of the condyles by fibrositic adhesions. Suppose that a cross-bite had swung the jaw habitually to one side; this could set up a conditioned reflex in the masticating muscles which would tend to hold the jaw to one side even after the removal of the teeth. But there are cases which are definitely not conditioned reflexes: the jaw will not straighten up after removal of the teeth. Mr. Campbell and his colleagues had investigated numerous cases of this type and had found that one condyle acted as a hinge; that is to say, as the mandible opened it swung to the affected side, held by adhesions presumably: it was not a true ankylosis, and the cause could seldom be traced. It bore little resemblance to the septic cases demonstrated by Mr. Greer Walker.

Sometimes the patient suffered pain and sometimes he had none. Sometimes it was the side with the adhesions that was painful; sometimes it was the mobile side, perhaps because it was too mobile. Mr. Campbell had been told by his orthopædic friends that this sort of pain was common in hip-joint disease; the fixed joint was free from pain whereas the more healthy side became overstrained.

Finally, a diagram was shown. Mr. Wilson, when referring to the cause of pain, had mentioned systemic factors. The diagram was intended to bring out this point of view. The figure represented a number of patients and the extent to which local versus systemic agents were responsible for pain. An oblique line separated one type of cause from the other: above the oblique line were systemic agents like rheumatism or psychogenic elements; below the line such things as displacements. At one end of the chart, one type dominated the scene whereas conditions reversed at the other.

Mr. Ritchie congratulated Mr. Wilson on his paper and said that a lot of cases had been described with cross-bite but what they had not heard was where so many of them began. His own view was that one had to look back a long way. As he had said before to the Society so he would say again, that one had to look at the age of 18 months when the deciduous canine was erupting. In many cases the children erupted their canine teeth in an edge-to-edge position and a two-point contact, and because that was a position of discomfort and poor mastication the lower jaw had to go either left or right or forward. If the condition was treated at that early age one overcame a lot of the problems, because all sorts of joint disorders could arise later in life. He was not for one moment talking about cases of injury, but cases of straightforward cross-bite which could become such a menace in adolescents from the orthodontic point of view. If orthodontists turned their minds to the very beginning when the canine teeth were erupting, they could save themselves a great deal of trouble later on.

Mr. Walpole Day asked how bad a clicking joint had to be before Mr. Wilson thought treatment necessary. His family always seemed to "come with him" on those occasions, but his brother had had a clicking jaw with which he had annoyed the family up to the age of 19 or 20 years. That had now completely disappeared, and he had had no treatment at all. During that time his only dental loss was that of his first permanent molars, and he was now 49 and not experiencing any trouble.

In addition, Mr. Walpole Day said he had a young daughter with a clicking jaw which she took a great delight in clicking, although she would stop when told not to do it. Both were Division 2 cases.

The Chairman said he wished to issue a word of warning. Those periodontal experts who were particularly interested in mandibular displacements, were originally inclined to treat all such cases whether or not there were symptoms referable to the mandibular joint. They had learnt, however, from bitter experience that if there were no symptoms the case should be left alone.

The Chairman concluded by saying that he thought the understanding of mandibular displacements had become much simpler as a result of the development of the concept that it was a reflex activity, which had not been developed only in this country but also by Thompson and his colleagues in America.

Mr. F. E. Hopper said he was very glad that the danger of interfering with occlusion had been brought out. He believed it was now generally agreed that traumatic occlusion as such could not cause periodontitis. That was why he queried the sort of picture which had been shown. In treating those conditions sometimes one was successful in locating the disorder which was responsible, but the cases which were not successful were conveniently forgotten, and while a large number of those cases could be treated if they were seen early enough, it was very difficult to say whether it was backward pressure or malocclusion, and he thought the vicious circle of muscle stress and spasm was as important.

Mr. H. E. Wilson, in reply, said Dr. Campbell had been very gracious and he could not compete with him in his experience of facial pain and disorders and diseases of the temporomandibular joint. He had put the position clearly in regard to the small part that orthodontics played in this problem in some, but not in all, cases. He also pointed out the scope it had in prevention, which agreed with his own views.

In one case there might be a gross condylar displacement and very few symptoms, and in another very little displacement and gross symptoms. The factors and the interplay of factors was very intricate and difficult to understand.

With regard to displacement it was necessary to start from some place and he had used the term "displacement" in referring to the mandible because it was a diagnostic aid in determining the future orthodontic

treatment. Of course, displacement of the mandible caused condylar displacement or condylar thrust so he used the term as meaning variation from the normal mandibular movement, which was upward and forward, an average of 3–4 mm. from the resting to the occlusal position.

Mr. Ritchie's point was a very good one, and Mr. Wilson said he had tried to illustrate that with the model of the young child who had come to him with a cross-bite which was treated by grinding the canines. The canines were almost always the guilty teeth in those early mandibular displacements.

Mr. Walpole Day had asked how bad a "clicking" should be before one interfered with it: a joint was not treated orthodontically just because there happened to be a "click" or because a condylar displacement happened to be recognized, but his point was that if one recognized a condition in a patient under treatment and it was within one's power to correct it, then it should be corrected. In established cases those complaining of symptoms were treated, but if there was a "clicking" without other symptoms, the paticnt was advised to try to prevent the "click", which was frequently possible, because with the appearance of other factors this might assume greater significance.

The Chairman had issued a warning about treatment, but of eourse one did not go in and treat patients just because they had a malocclusion. It was possible to get a gross malocclusion with very healthy gingival conditions, no sign of mandibular joint disorders, and producing no displacement. (He had intcnded to inelude one slide of a very gross lateral cross-bite from one to seven on the one side, the upper incisors biting between the lower right and left central incisors. A gross mandibular displacement but no symptoms.) At the same time, it was not usual to treat all orthodontic conditions for the sole reason that they might be a factor in producing a paradontal condition later.

With regard to the point about lateral tongue thrust he was fairly well convinced that he had observed it, and whether or not one could see the reason for it he was sure it existed. He had put in appliances of the monobloc type in children where there was a large free-way space: this was not universal but was his technique. There might be some error in estimating either the space or the relation of the size of the tongue to the size of the dental arches. It was a very difficult thing to prove scientifically, but that did not mean it did not exist, and, though it might be rare, there were individuals who might have that condition. It was not an easy thing to determine. He had noticed that one could see the impression made by the molars biting on the side of the tongue.

The reflex activity he was aware of and should have mentioned but did not quite know what emphasis to put on it. There were many conditions which could be noticed in the individual but could not be statistically presented as they could not be produced in sufficient numbers and varied so much from individual to individual. He was not certain that this reflex movement existed, certainly not in all cases, but it could be overcome. The distal mandibular displacement could be corrected as illustrated in the case of the girl who had four first premolars extracted.

In reply to Mr. Hopper, Mr. Wilson said he was not trying to over-emphasize the importance of this approach. They did not interfere for the sake of interfering; there was much work to be done and they did not need to look for it. Generally, those who complained of symptoms were treated and, as shown by Dr. Campbell, there was a great difference in the factors involved: sometimes one was more important than the other and at other times their relative importance changed. It was very difficult in the first plaee to determine all the factors which were acting at one time, and secondly, it was very difficult to determine *to what degree* they were acting. There might be half a dozen faetors, of which "A" was the most important at one time and "B" at another, but because there was crowding of the teeth which might be a factor, they did not automatically dash in and say "We must correct this". The problem in orthodontic treatment was to try to determine if, in view of the amount of work involved, the result would be better in all respects than the present condition. If not, it would be better left alone.

A vote of thanks to Mr. Wilson for his paper and to Mr. Campbell for opening the discussion was proposed by *The Chairman*, who said that although they might disagree on many points it was important that they should be brought forward for observation.

The vote of thanks was aecorded with acclamation and the Session then terminated.

A SYMPOSIUM ON CLASS II DIVISION 1 MALOCCLUSION

I. MORPHOLOGY IN RELATION TO TREATMENT PLANNING

By Professor **C. F. BALLARD,** F.D.S. R.C.S., M.R.C.S., L.R.C.P., D.Orth. R.C.S.

As this is the first paper in a symposium on Class II division 1 cases, its purpose is to summarize the morphological features which produce this type of abnormality of the dento-alveolar structures and to indicate their significance in relation to treatment planning and prognosis in terms of the possibility or otherwise of producing a stable normal occlusion.

For the sake of brevity the author has had to assume that readers agree with the concept that the position of the dental arches, normal or abnormal, are the result of soft-tissue morphology, patterns of motor activity of the soft tissues, and skeletal morphology; that clinical experience has now proved that in treatment the skeletal morphology cannot be changed by orthodontic treatment; and that soft-tissue morphology and its behaviour are only adaptable in certain limited ways, to be discussed in this paper.

These concepts infer that it can no longer be accepted that postnatal environmental factors play an important part in the production of malocclusions. It will be argued later that thumb-sucking is not an important cause of malocclusion and the author states dogmatically that those who believe that early loss of deciduous teeth can produce Class II division 1 and Class III malocclusions are blind to the morphological features always associated with these malocclusions. Early loss of teeth, however, may complicate treatment out of all proportion to the original condition.

A cephalometric analysis of 105 cases of Class II division 1 out of retention has confirmed that statements which have been made previously, based on clinical experience, are correct. It was hoped to relate statistically the stable changes that had occurred to the clinical analysis of soft-tissue morphology; however, this was found to be impossible because over the last five years descriptions of lip morphology and tongue behaviour, etc., had changed a little and become more definite.

Some of the facts that are evident from this analysis will be mentioned later, but it must be stated now that there was no evidence that treatment had changed the dental base relationship, or that it had changed even as a result of normal growth during the period covered by the lateral radiographs. In five cases, evidence to the contrary could have been produced, but only if the fact that habitual positions of the mandible as distinct from the endogenous position do occur and should be found in the clinical examination. This will be discussed later.

Class II division 1 malocclusions are the result of a combination of morphological features, mainly inherited, which can be discussed under the following headings: (1) Skeletal (dental base relationship); (2) Soft-tissue morphology; (3) Patterns of motor activity of the soft tissues; (4) Local factors within the dento-alveolar structures.

Again for the sake of brevity, it is necessary to tabulate the factors and then briefly define them where necessary.

Class II Division 1 Morphology. Classifying the Malocclusion on the Basis of Labial Segment Relationship rather than Molar Relationship.—

1. *With a Class I Dental Base Relationship.—*
   a. Incompetent lip morphology.
   b. Atypical swallowing behaviour.
   c. Incompetent lip morphology and atypical swallowing behaviour.
   d. Other variations of orofacial morphology or behaviour (may be associated with *a* and *b*).

Given at the Newcastle upon Tyne meeting held on May 12, 1956.

2. *With a Class II Dental Base Relationship.*—

a. Competent lip morphology.
b. Incompetent lip morphology.
c. Atypical swallowing behaviour.
d. *b* and *c* together.
e. Other variations of orofacial morphology and behaviour.

Sub-division: Mandibular labial segment proclined in soft-tissue balance to completely or partially compensate for the postnormality of dental base relationship.

From long clinical experience the author believes that the best method of assessing dental base relationship is that which originated at the Royal Dental Hospital ten or more years ago (Ballard, 1948, 1953). It is suggested, however, as a result of cephalometric analysis of a large number of cases that it is better to use the maxillary plane instead of the Frankfort. The mean values of 250 unselected individuals are given in *Fig.* 1 A, and *Fig.* 1 B shows the use of these as previously described to assess the degree of postnormality of the mandibular base in relation to the maxillary base.

The primary feature of treatment of any Class II division 1 malocclusion on a Class II dental base is to have the lower labial segment as much labially proclined as soft-tissue posture and behaviour will permit to remain stable, compensating as far as is possible for the postnormality in the skeletal morphology (Ballard and Walther, 1953).

In planning treatment it is important to realize that the buccal segments in contact with the labial segment contribute to its stability in the proclined position. In other words, in an intact arch with all teeth in contact, the buccal segments must be recognized as a factor, with the tongue, in balancing lip activity. From clinical experience supported by cephalometric analysis one is inclined to say that this factor in the lower arch is the equivalent of about 4° of labial inclination. It is a finite amount and the oft-repeated statement that the farther back the extraction the less the collapse, cannot be supported by clinical and cephalometric analysis. Extractions back to and including the first permanent molars will result in a definite amount of lingual collapse comparable to the amount that the buccal segment or segments contributed to the stability of the labial segment.

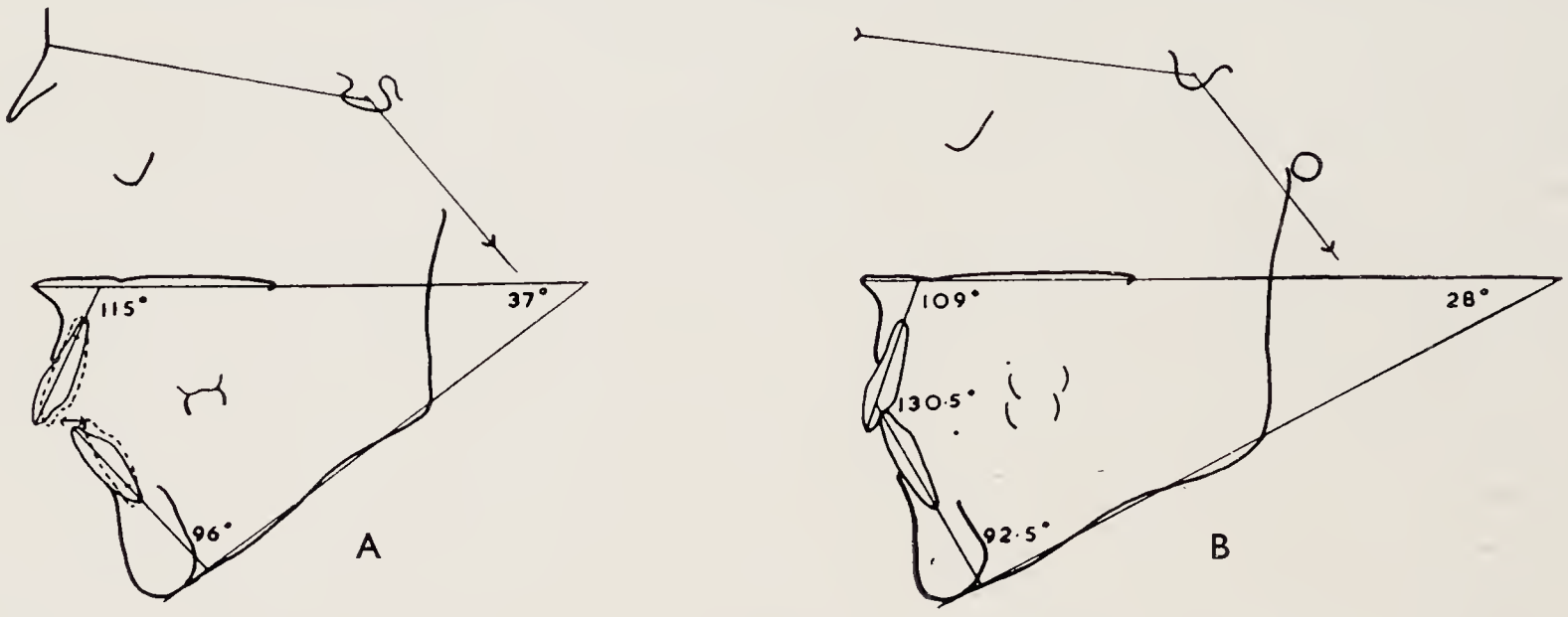

Fig. 1.—A, A tracing constructed around the mean values of 250 random selected individuals. B, Shows the method of correcting axial inclinations of upper and lower labial segments to the mean values to demonstrate the dental base relationship. *N.B.*—$\overline{1|1}$ to mandibular plane angle varies inversely as the maxillary-mandibular plane angle (Ballard, 1951).

The essential factors within the dento-alveolar structures, therefore, excluding the complication of early loss of deciduous teeth are the relationship of the buccal segments to the Class II division 1 position of the labial segments and the way in which their position contributes to the abnormality.

In both arches the buccal segment can be:—

1. In contact with the labial segment.
2. Forward of the labial segment producing overlap of canines over laterals and incisor crowding—anteroposterior crowding.
3. Spaced from the labial segment.

Now to go back and discuss briefly how these various morphological features contribute to the aetiology of the malocclusion and influence treatment and prognosis:—

Incompetent lip morphology has been discussed before, but has never been clearly defined and for diagnostic purposes it is important to do so. First, however, competent lip morphology must be defined. It is as follows:—

With the mandible in its endogenous postural position (physiological resting posture, Thompson, 1949), and the muscles of facial expression in resting posture, the lips are in contact maintaining an anterior oral seal. The endogenous posture of the mandible and of the facial muscles can be shown electromyographically as the position of electrical silence when the individual is standing or sitting upright unsupported (Tulley, 1953; Perry, 1955; Shpuntoff and Shpuntoff, 1956).

Incompetent lip morphology is a failure of the lips to produce an anterior oral seal when the mandible is in its endogenous postural position and the muscles of facial expression are similarly in "resting" position. The significance of incompetent lip morphology is that to produce an anterior oral seal there has to be circumoral contraction, and as a general rule the mentalis muscle and the orbicularis oris muscle in the lower lip are more active than the orbicularis oris muscle in the upper lip.

With incompetent lips on a Class I dental base relationship, a Class II division 1 labial segment relationship can be produced by the combination of two factors:—

1. The contraction of the mentalis and orbicularis oris muscles maintaining the lower labial segment in a more lingually inclined position than would otherwise be the case.

2. The open lip posture not maintaining an adequate restraining influence on the upper labial segment when there is anteroposterior crowding in the maxillary arch, the tendency for the buccal segments to move forward increasing the factor of the support of the buccal segment to the labial segment and producing some degree of proclination.

Evidence of the latter factor comes from the fact that in such cases removal of $\frac{4|4}{}$ frequently results in complete reduction of the overbite by the dropping back of the upper labial segment without any active treatment.

It is important to realize that, except in very mild degrees of incompetence associated with a bimaxillary proclination which has been reduced a little by treatment, incompetent lip morphology cannot by exercising or conscious effort become a competent lip morphology; although, according to the degree of incompetence an anterior oral seal may be maintained by contraction of the circumoral musculature either subconsciously or by conscious effort before or after orthodontic treatment. It is also necessary to appreciate that in extreme degrees of incompetent lip morphology no effort should be made to maintain a lip seal as a habitual posture, the necessary circumoral effort spoiling the appearance of the individual. On a Class II dental base relationship, the significance of the contraction of the musculature of the lower lip is that, except in very mild cases, any treatment which proclines the lower labial segment, although theoretically right from the point of view of compensating for the postnormality of the dental base, will inevitably relapse.

As was discussed last year it is now fairly certain that in diagnosis we must distinguish between the endogenous tongue-thrusting behaviour and that which is a habit activity (Ballard, 1955). The latter arises as part of the pattern of activity to produce an anterior oral seal when the labial segment relationship is abnormal as in Class II division 1 and Class II division 2. If the treatment produces a normal labial segment relationship the habit activity disappears. Since last year the author has found that Fieux (1953) was probably the first to suggest that some atypical swallowing behaviours were habits only.

The endogenous type of tongue thrust was probably first noticed by Froeschels (1937), who found that sigmatism was due to tongue position and activity and not due to malocclusion. He said protrusion of tongue between teeth was performed with undue effort. In 100 cases examined he found that in only 6 of them was the anterior open bite sufficient

to permit a protrusion of the tongue without an opening of the jaws. The severity of the sigmatism when present in these cases appears to be directly related to the degree of abnormality of the dento-alveolar structures and hence to the degree that the thrusting behaviour

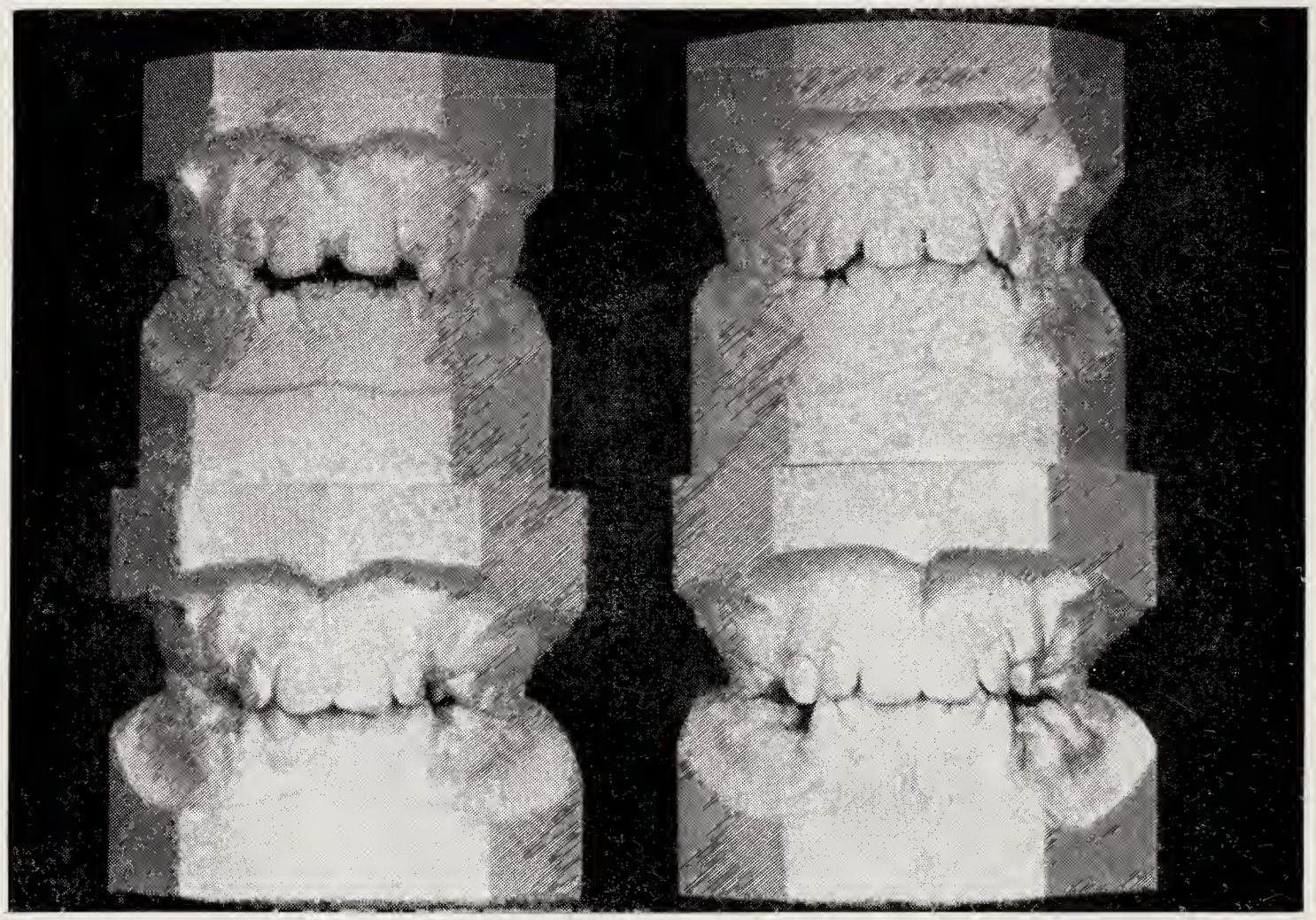

Fig. 2.—Serial models showing slow reduction of an open bite without treatment in a tongue-thrusting case.

is abnormal. In most cases there is spontaneous disappearance of the speech defect by about 10–11 years of age. In such cases there is also improvement in the labial segment relationship without treatment if other factors permit (*Fig.* 2). In a few cases the sigmatism is controlled after training by a speech therapist and there is a small percentage of individuals who cannot control the tongue sufficiently to eliminate the sigmatism however much conscious effort they apply. In all these cases the tongue behaviour does not change as far as can be seen clinically.

From clinical observation the author now believes that the endogenous tongue-thrusting behaviour does not produce a Class II division 1 labial segment relationship. If the other morphological features would produce a Class I labial segment relationship then the abnormality produced is either an open bite, or if less severe, a slowly improving open bite as stated above. If, on the other hand, other morphological features such as incompetent lips or a Class II dental base relationship are present, then the tongue thrust will contribute to the Class II division 1 labial segment position. Theoretically, therefore, treatment should be planned in relation to the other morphological features and the tongue-thrusting ignored. Many will disagree with this, but so far the stable results achieved over the last five years support this approach.

Under variations of expressive behaviour the most important is that which consists of a firm retraction of the lower lip during expressive behaviour and speech (Ballard, 1953). This retraction appears to come from the modioli and orbicularis oris; it is not a contraction of the mentalis muscle. The upper lip in such cases does not retract, but frequently everts or pouts a little in expressive behaviour. In such cases the dental base relationship is usually slightly postnormal, with a well-developed mental eminence. The lips are competent. The lower labial segment is usually lingually inclined and in no case has a proclination remained stable. It is aesthetically unsatisfactory to retract the upper labial

segment back to the lower in such cases. The increased overjet, therefore, must only be reduced and not completely eliminated. This pattern of activity is frequently a family characteristic, which supports the view that patterns of activity are inherited.

Finally, there is a combination of competent lip morphology on a Class II dental base relationship in which the lower lip is lingual to the upper incisor teeth. In such cases the increased overjet may or may not be associated with a proclined upper labial segment, although lip tongue balance in relation to the lower labial segment has not produced a relatively proclined position to compensate for the Class II dental base relationship. The significance of the combination of competent lip morphology on a Class II dental base relationship is that the lower labial segment can be proclined to compensate either completely or partially for the postnormality of dental base relationship. This means, in fact, that the whole of the lower arch can be brought forward. With this type of case it would appear that as much as 10° of change of axial inclination labially of the lower labial segment will remain stable.

This type of case is frequently said to be due to lower lip sucking. It is, however, the Class II dental base relationship which is the primary fault and it is doubtful whether there is any true lip-sucking behaviour involved. Cases illustrating this type were shown by Ballard and Walther (1953).

Having determined from the study of morphology and behaviour where upper and lower labial segments will remain stable at the end of treatment, it is necessary to assess what adjustment of the buccal segments is required in relation to the proposed change of labial segments. Either the buccal segments can be moved anteroposteriorly or extraction may be required.

First, to deal with the maxillary arch. If the labial segment is proclined, and the buccal segment is in contact with it, then during treatment either the buccal segment must be moved distally or retraction of the labial segment must follow the removal of a unit in the anterior part of the buccal segments. Distal movement of buccal segments is only possible: (*a*) if the dental base is long and there is potentially space posteriorly; (*b*) there is adequate anchorage either in the mandible or extra-orally. Distal movement can be assisted by removal of second permanent molars in suitable cases. In such cases the same amount of anchorage is not required.

When the buccal segments are forward of the labial segments, whether or not it is proclined, then, as a general rule, this indicates that the arches are short anteroposteriorly and extractions in the anterior part of the arch are indicated. However, occasionally distal movement of buccal segments with or without extraction of $\underline{7|7}$ is satisfactory when there is about half a unit bilaterally of anteroposterior crowding. Spacing in the maxillary arch in a Class II division 1 malocclusion frequently means that treatment is very simple, no extractions are required and only slight distal movement of first permanent molars is necessary and easily accomplished.

In the mandibular arch the whole treatment plan revolves round three factors:—

a. Whether soft-tissue morphology and behaviour would permit the forward movement of the lower arch with a proclination of the labial segment.

b. Whether there is anteroposterior crowding in the lower arch.

c. How much anchorage is required in the lower arch for treatment of the maxillary arch. If the lower labial segment can be proclined, then the lower arch can be used for anchorage until it has been decided that the lower labial segment has been proclined the amount that the soft tissues will permit. If, at this stage, sufficient distal movement of the maxillary teeth has not been achieved, then the possibilities are either to use some extra-oral anchorage or, alternatively, to extract, and if the case has been planned correctly, it would at this stage be second permanent molars. If there is anteroposterior crowding in the mandibular arch and the lower labial segment can be proclined, then the treatment is anteroposterior expansion in the mandibular arch without using it for Class II traction. In other words, find the space for the crowded canines

by proclining the labial segments, leaving the buccal segments where they are. If there is anteroposterior crowding in the mandibular arch and the lower labial segment must not

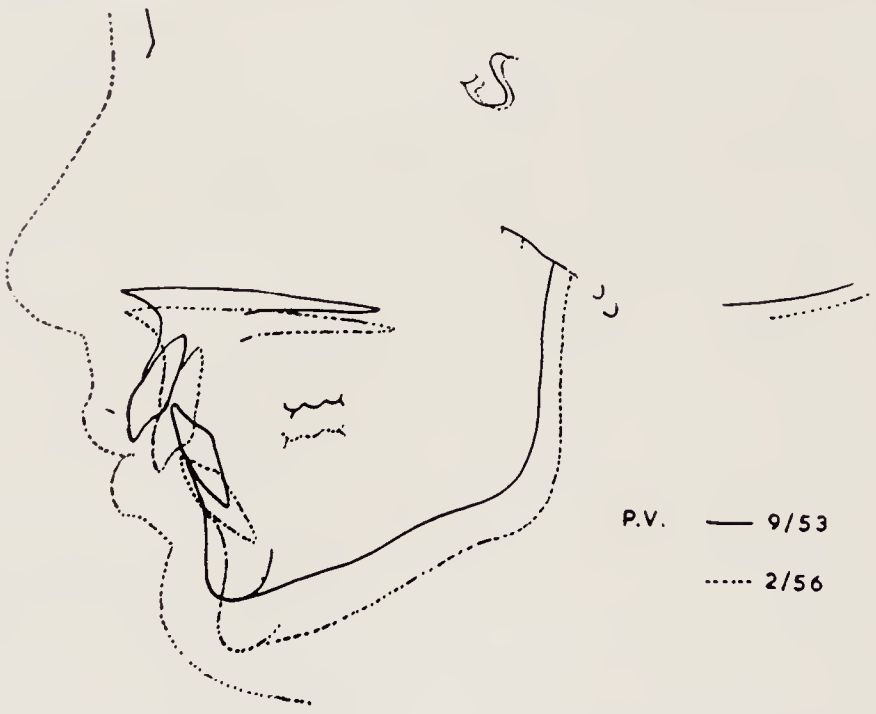

Fig. 3.—Superimposed tracings before and after treatment demonstrating bodily retraction of upper incisor teeth.

be proclined, then, as a general rule, treatment is the removal of a unit bilaterally, usually the first premolars, and the use of some Class II traction to close up residual spaces so that there is no risk of the lower labial segment collapsing lingually. If there is spacing in the mandibular arch, then the buccal segments can be used for Class II traction until the spaces have been closed, thereafter only continuing with traction if some proclining of the labial segment is permissible.

Finally, it should be said that the mandibular arch can be used for light Class II traction, even if it must not be brought forward, if adequate anchorage to the whole arch is established. This can be done with a removable appliance and a labial bow.

Brief mention should be made of the fact that in previous papers the author has said that on a Class II dental base relationship with incompetent lip morphology the end-result is frequently poor (Ballard, 1953), because the upper labial segment has to be lingually inclined in the stable end-result. There is some hope of achieving a less unsatisfactory end-result if a technique is used which produces some palatal movement of the apices of the upper incisors as their crowns are retracted (*Fig.* 3) (Holdaway, 1956).

However, there is a limit to this type of tooth movement, and undoubtedly many of the extreme degrees of Class II dental base relationship that are seen in this country will not be greatly benefited by such a tooth movement. The width of the dental base may not be the only limiting factor, but the relationship of the incisal tip to lower lip may be important for stability, a lingual inclination of the upper incisors with their incisal tip inside the lower lip being in some cases essential.

Mention must be made of habit activities in relation to Class II division 1 malocclusions. First, those associated with mandibular posture. As has been previously stated, many individuals with a Class II division 1 type of overjet posture forward habitually in order to assist in the maintenance of an anterior oral seal. This habit position is downwards and forwards from the endogenous postural position (physiological rest position). If it is mistaken for and cephalometrically recorded as the endogenous postural position, then the cephalometric analysis of before and after positions of the mandible would seem to indicate that the mandible is farther back at the end of treatment (Ricketts, 1952).

The author would also suggest that it is this habitual position of the mandible which caused Moyers to find abnormal patterns of activity of the muscles in Class II division 1 cases. This habit activity, of course, disappears when the increased overjet has been eliminated by treatment. It is also important to realize that this habit postural position is almost invariably associated with a tip of tongue to lower lip contact in the production of an anterior oral seal. When this is so, there is a habit activity of tongue-thrusting which has been previously mentioned in this paper, and was discussed in greater detail last year (Ballard, 1955). This type of habit activity is not only present in Class II division 1 cases before treatment, but it can also be induced in a certain type of case as the result of treatment. The author is convinced that many cases reported as excellent results of Class II division 1 malocclusion only appeared so good because they were the types in which the treatment induced the forward posturing. If in such cases they are

asked to bite for the purpose of recording occlusion cephalometrically, they almost invariably close in the forward position, giving a false mandible-to-maxilla relationship. On cephalometric analysis it would appear that the mandible has been made to grow forward.

Fig. 4.—Shows the lateral radiograph in occlusion before treatment and lateral radiograph in the forward posturing after treatment.

From an analysis of the cases which have been recorded at the Eastman which show habit posturing at the end of treatment, it is possible to state that the usual morphological features are as follows:—

1. A Class II dental base relationship associated with an average or below average maxillary-mandibular plane angle.
2. A competent lip morphology.
3. The upper incisors resting either into or just in front of the lower lip, but being almost completely covered by the upper lip.

Before treatment an anterior oral seal is produced with considerable contact of the tongue against the lower lip; after the treatment has reduced the overjet only a small amount, the habit changes its pattern, the overjet is partially eliminated by a downward and forward posturing of the mandible until the tip of the tongue contacts the lower lip between the upper and lower labial segments. During mastication the mandible goes back to its centric position. This is not a true displacing activity. *Figs.* 4, 5 illustrate such a case.

It only remains to mention the habit of finger- and thumb-sucking. The author realizes that it is, at this stage, quite impossible for him to prove his statement, but he is convinced that clinical and cephalometric observation of the position of the dento-alveolar structures in relation to the morphological features that have been discussed both before and after treatment, and in relation to the relapses that have followed attempts to treat, leave no doubt whatsoever that finger- and thumb-sucking is only very rarely the cause of a Class II division 1 labial segment relationship. The

habit of finger- and thumb-sucking, in fact, will only contribute to a Class II division 1 labial segment relationship if the other morphological features will produce such relationship without the habit. The majority of Class II division 1 cases which present to an Orthodontic Clinic give no history whatsoever of finger- and thumb-sucking. On the other hand a large number of Class I dental base relationship cases, Class II division 2, and Class III labial segment relationship cases give a history of persistent thumb-sucking and by no stretch of imagination could the habit have contributed to the occlusal abnormality.

Finally, it must be said that the paper is an abbreviated version of that presented to the Newcastle Meeting, and references to the works of authors whose observations have contributed to the conclusion reached have had in the main to be omitted. As far as orofacial behaviour is concerned the most important are Rix, Gwynne-Evans, Tulley, and Hovell, and as far as mandibular posture and movement are concerned the original work was done by Thompson, and a considerable number of men have contributed to our knowledge both by clinical observation and electromyographic research.

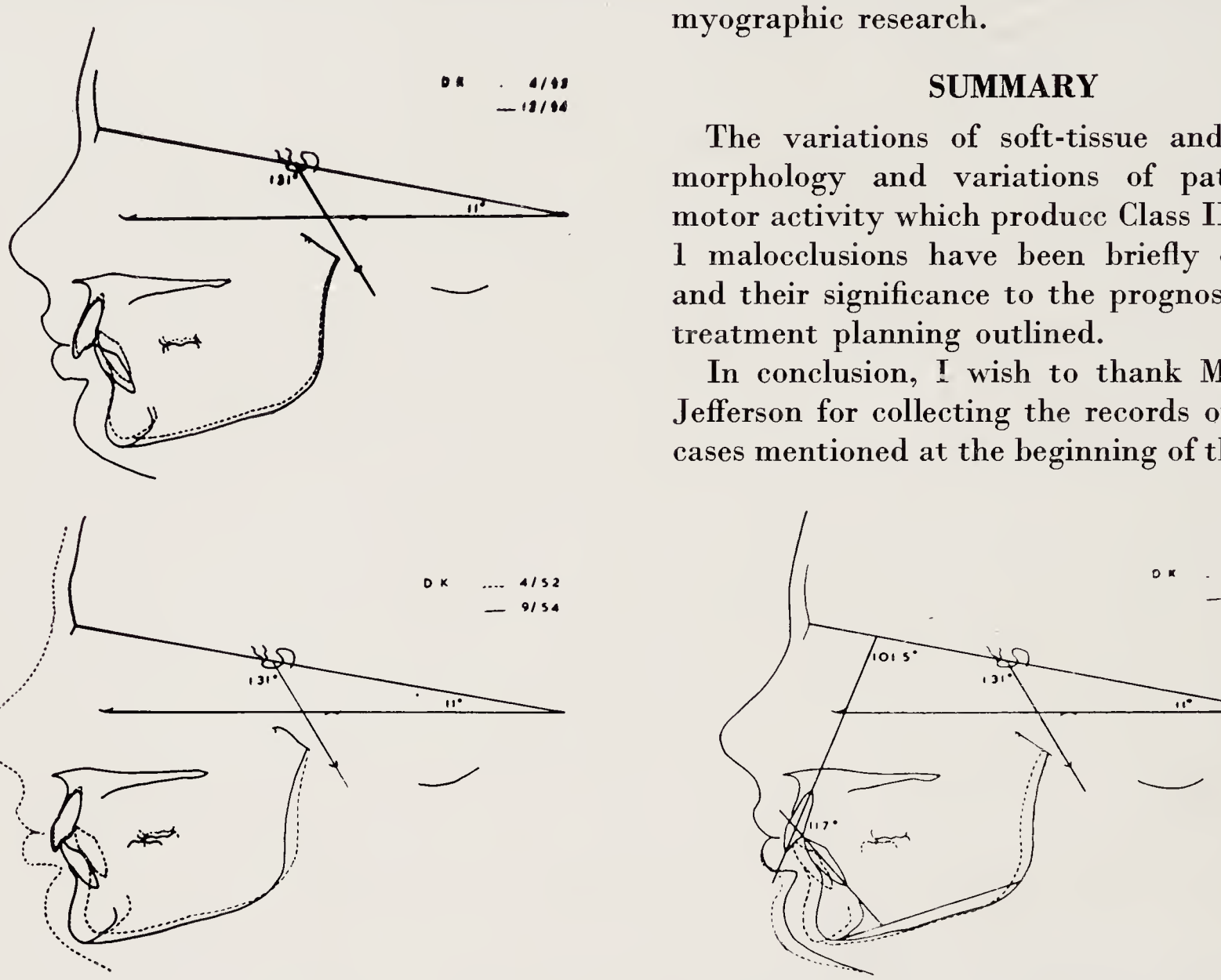

Fig. 5.—Same case as *Fig.* 4. Superimposed tracings in centric and forward posturing positions before and after treatment.

SUMMARY

The variations of soft-tissue and skeletal morphology and variations of patterns of motor activity which produce Class II division 1 malocclusions have been briefly described and their significance to the prognosis and in treatment planning outlined.

In conclusion, I wish to thank Miss C. C. Jefferson for collecting the records of the 105 cases mentioned at the beginning of the paper; and Mr. Morgan, of the Photographic Department of the Institute of Dental Surgery, for the illustrations.

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DISCUSSION

Mr. Mills said he had listened with great interest to Mr. Ballard's paper. He wondered if he had misinterpreted Mr. Ballard. As he had understood it the author saw two important factors in the soft tissues. The first was an open lip posture, in which apparently the important thing was the incompetence of the lips at rest and not any functional activity of them. The second was the thrusting action of the tongue on swallowing. Some time ago Mr. Rix had read a paper before the Society in which he described two types of abnormal swallow associated with Class II division 1 malocclusions. On the one hand there was a type in which the posterior teeth were apart, the lower lip contracted violently against the lower incisors, and the tongue was protruded over the tips of the lower incisors. This produced a Class II division 1 malocclusion with a deep over-bite. Would Mr. Ballard agree that this was the type which was associated with the incompetent lip posture, and if so, would he agree that the important thing was the contraction of the lower lip to meet the tongue in swallowing, rather than the incompetence of the lips at rest?

The other type of swallow, where the tongue was thrust forward between the anterior teeth, with much greater force and frequency, produced an anterior open bite with or without a superior protrusion. Would Mr. Ballard agree that in the former case the lower lip was the important factor, and in the latter the tongue?

Arising out of this Mr. Mills wished to enter a plea for some standardization of terminology. It did not matter to those who were teaching because they knew what different people meant by the different terms used, but when candidates had to be prepared for the examinations which were held by two Royal Colleges it was difficult if there was more than one terminology. Would it be possible for the Society to do something in the matter?

Mr. Ballard, in reply to Mr. Mills, said he was sorry he had not made the point clear. From the point of view of diagnosis the obvious feature was the lips-apart type of passive morphology, but from the point of view of treatment the important thing was that the lower lip contracted every time the individual swallowed, it contracted during speech, and in the production of an anterior oral seal, so it was really the activity of the incompetent lip posture which was the important thing.

The other important diagnostic point was that when the lip contracted it was not necessarily contracting against a tongue thrust. Again, that was why the records were not sound. Five years ago if they had seen a lower lip contraction "à la Rix" they would possibly have assumed in a number of cases that the tongue was thrusting forward, but that was not so. The other confusing thing, of course, was that when one had an increased overjet associated with incompetent lip posture then the tongue as a habit activity came into the production of an anterior oral seal. One of the things which had to be done over the next few years was to attempt to differentiate quite distinctly between that tongue activity which was not, he believed, a true tongue thrust but a habit activity which would disappear when the increased overjet was reduced and the tongue activity which was probably an endogenous behaviour.

With regard to terminology, Mr. Ballard said he was probably a great offender in inventing terms like "endogenous postural position", and it was not for him to tell everybody that they should give up the use of the term "physiological rest position", but one of the reasons for using the term "endogenous postural position" was that it described what he believed to be the true physiological situation; in other words it arose within the central nervous system. If one turned an individual upside down the physiological position was still maintained.

Mr. Breakspear asked whether he had heard Mr. Ballard aright at the beginning of his paper when he believed he said that in addition to the 5 cases which he described there were also another 5 where he had seen some change in the dental base relationship.

Secondly, it had appeared that in one of the cases the molar relationship was still left in the Class II position: was that correct or not?

Mr. Ballard, in reply to Mr. Breakspear, said he was sorry but he had so much ground to cover that he had just been summarizing the situation as he saw it. He frankly had not seen any change in 100 cases: there were not another 5 cases where there was any appreciable change, but just the 5 cases which he had explained.

He had not been particularly concerned about molar relationship on that occasion. The important thing obviously was that when changing the position of the labial segments the treatment had to change the position of the buccal segments relatively. He was not particularly concerned about what had happened to molar malocclusion, but they had in fact extracted from the upper arch so that it might remain Class II.

Mr. Walpole Day asked about the selection of the 100 cases, as Mr. Ballard had not said exactly how they were selected but only that 5 had been rejected. Were any of the 100 cases finger-suckers or thumb-suckers up to the time of starting treatment, and were any of them mouth-breathers?

Mr. Ballard, in reply to Mr. Walpole Day, said the selection of the cases actually consisted of the first 100 they came across when going back over the records. When a case was completed it was graded—in other words if the records were not satisfactory it was thrown out, possibly because somebody had lost the model or a radiograph was not taken at some time, but of the cases where it was known that the records were complete it was the first 100 cases, working backwards.

He was unable to answer the question about thumb-sucking satisfactorily because over the last five years —and it would happen over the next five years—with regard to soft-tissue morphology their ideas were changing all the time, so that something which was said five years ago did not mean the same thing now. Roughly 18 per cent of the cases gave a history of finger- or thumb-sucking at some time or other, but that was all he was able to say about it.

With regard to mouth-breathing, from the point of view of Gwynne-Evans's work none of them was a mouth-breather. In other words a high percentage of the incompetent lip posture individuals went about with their lips apart but they were not mouth-breathers because they had a tongue to soft palate seal. That was obvious from the radiographs, so without actually having the figures available he would say that none of them was a true mouth-breather.

Mr. Glass, referring to the problem of the planes and angles, said they had seen the angle from anterior to posterior nasal line, which appeared to be an advance

on any other line because it was within the maxillary complex of bone; the only problem was that the descent of the palate did not bear direct relationship to the growth of the palate as such, and the anterior part did not descend parallel but like a plate falling through water. Did Mr. Ballard think it was sufficiently stable to build up angles of treatment?

Also, Mr. Ballard had talked about posturing forward and had shown cases where there was a bad occlusion in the premolar region, but he had not talked about posturing back. Afterwards the child would probably start sucking his thumb and by an expansion of the upper arch one found quite soon afterwards that it was not necessary to do any more because the child was posturing to the forward position, which was normal, and the original posture was a bad one.

Mr. Ballard, in reply to Mr. Glass, said with regard to the maxillary plane it was interesting that the mean values which they had been working out through the various age groups coincided very closely; they were never more than 1° out, and as a rule only 0·5°. One had to use angles in order to illustrate the clinical approach, but within a degree or two it did not really matter, and he felt certain that the maxillary plane during the development of the individual did not change a significant amount.

Referring to the question of posturing, Mr. Ballard said he frankly did not believe Mr. Glass, and he would have to see it demonstrated cephalometrically before he would believe it. If the mandible postured back a significant amount he did not quite see what happened in the condyle, and as he had said on many occasions he had not thought up the idea of the dental base relationship not changing. He had been trying to show what happened, and would be only too pleased if he could demonstrate that the dental base relationship did change as a direct result of treatment. He did not consider that the alveolar structure had changed, although he knew what Mr. Glass meant: in the Class II division 2 cases in particular one expanded the maxillary arch a mere fraction and the occlusal relationship changed half a unit within a matter of months. He could not explain it but he knew it gave one a false idea of what would happen in the end.

The Chairman (Professor G. E. M. Hallett), referring to the matter of the physiological position being maintained when one was upside down, said that this was probably true but on the only occasion when he himself had tried to hang by his feet, he had developed a violent headache and found it impossible to analyse his own muscular reactions. Did Mr. Ballard know any real scientific investigation of the matter?

Mr. Ballard, in reply to Professor Hallett, said having heard it said, rather facetiously, that if one hung over the side of the bed the mandible did not maintain its postural relationship he had immediately instituted a piece of research, in that he went home and turned himself upside down and found that his mandible did maintain its postural relationship.

Mr. Logan thanked Mr. Ballard for his as usual extremely lucid and most interesting paper. He was afraid, however, he agreed with Mr. Glass about the question of the bases. He believed that the position of the lower base did change; it could be moved forward and back, and the reason this could not be demonstrated cephalometrically was that in the cephalometric method the inherent error was greater than the actual movement which took place. That did not mean that the movement did not take place, but that the method was not a suitable one for demonstrating it. Clinically they had probably all seen it, and he found no difficulty in believing that the condyle moved forward slightly in the joint.

He felt a plea should be made at this stage for a Controller of Orthodontic Jargon. Take, for example, the term "soft tissue morphology": "morphology" was defined as the study of shape, and if his ears had heard correctly this morning the term had been used for two quite different ideas, one being the shape of the soft tissues. As such it was used in the context "the teeth were moved as a result of soft-tissue morphology". This did not mean that they were moved as a result of the study of soft tissues, which is what the phrase means in any literate company. It made things exceedingly difficult for students and it was quite time that certain orthodontists pulled themselves together and stopped using the term "morphology" when they meant "shape". Other and more egregious examples were to be heard from time to time in their discussions.

Mr. Ballard, in reply to Mr. Logan, said with regard to the cephalometric analysis of dental base relationship, he did not know whether Mr. Logan had looked at a very large number of tracings, before and after, but he personally must have looked at five or six thousand over the last ten years, and the changes that he saw were not significant. The visual impression of the patient was just not borne out by what one saw in the tracings, and as he thought someone would bring up the question of the inherent error, he had tried to demonstrate that it did not matter.

Referring to the control of jargon, Mr. Ballard said the difficulty was that the words used were not orthodontic expressions. Before they used the term "soft-tissue morphology" and "morphology of behaviour", which was even more incorrect, other people had already used them. Gesell twenty years ago had been using those expressions and they had only copied him. Admittedly an attempt should be made to define exactly what they meant. There was tremendous confusion at the moment between things like "intra-occlusal clearance" and "free-way space"; even the periodontal people used those terms in different ways.

II. TREATMENT

By **W. H. LITTLEFIELD**, B.D.S., H.D.D. R.C.S., D.Orth. R.C.S.

STRICTLY speaking, of course, the term Class II division 1 malocclusion should be reserved for that type of malocclusion where the mandibular arch is distally related to the maxillary arch by half the width of the first permanent molar, or the entire width of a premolar, and where the maxillary incisors are in labioversion. In practice, however, many malocclusions are encountered where there are definite signs of Class II division 1 malocclusion but where the mandibular arch is distally related to the maxillary arch by an amount which is less than the entire width of a premolar. For example, in some cases, the mandibular arch is only half a premolar width distal to the maxillary arch and the lower teeth occlude cusp to cusp with the upper teeth. These, what one might term tendencies to Class II division 1 malocclusion, are frequently seen and often require treatment. It is felt, therefore, that they should be included in this paper.

The purpose of this paper is to consider the treatment of Class II division 1 malocclusion. In practice, however, before treatment is commenced a number of factors must be considered. Consequently the subject will be dealt with under two main headings:—

1. Factors to be considered before treatment is planned.
2. Principles of treatment with examples of treated cases.

FACTORS TO BE CONSIDERED BEFORE TREATMENT IS PLANNED

It is of course always necessary to consider all such factors as the patient's age, circumstances with regard to schooling, travelling, and possible co-operation, the patient's health, the teeth themselves with regard to caries, pathology, malformation, and absence, and the condition of the periodontal tissues. In addition the following should also be considered:—

Relationship of Size of Teeth to Size of Bone.—The relationship of the size of the teeth to the size of the bone needs to be assessed, the degree of spacing or crowding being noted. As a general rule, where the teeth are spaced, no extractions are indicated and, where there is slight crowding, it may only be necessary to extract teeth from the upper arch. However, where severe crowding is present, one is often obliged to extract teeth from the lower arch and these lower extractions frequently decide which upper teeth must be removed.

Cause of the Labial Segment Relationship.—The cause of the abnormal labial segment relationship seen in Class II division 1 malocclusion must always be carefully studied. Much of course has been written on this subject, but a simple view would seem to be that there are two major factors which cause the increased overjet seen in Class II division 1 malocclusion. These are the skeletal pattern (i.e., the relationship of the lower apical base to the upper apical base) and tilting of the upper and lower labial segments on their respective apical bases.

1. *Skeletal Pattern.*—Where the lower apical base is posteriorly related to the upper apical base there is obviously a tendency for the lower incisors to be posterior to the upper incisors and, in practice, a number of cases of Class II division 1 malocclusion are seen where the apical base relationship appears to be the sole cause of the increased overjet.

2. *Tilting of the Labial Segments.*—The upper and lower labial segments become tilted on their apical bases owing to the position and action of the lips and tongue and also owing to habits. Commonly the upper incisors are proclined and more rarely the lower incisors are retroclined. Consequently, cases of Class II division 1 malocclusion are seen where the apical bases are normally related and the sole cause of the abnormal labial segment relationship is tilting of the labial segments.

However, in practice, many cases are found where these two major factors are mixed. In some the main cause is the skeletal pattern, whilst in others it is tilting of the labial segments.

Therefore, when considering the cause of the labial segment relationship of a Class II division 1 malocclusion, the skeletal pattern

should be carefully assessed. Now the consensus of opinion seems to be that, with the appliances in general use, it is not possible to alter the skeletal pattern, and my own experience is that, at any rate, it is better to work on the assumption that it will not be altered. Therefore, in the first type of case, where the skeletal pattern is the sole cause of the excessive overjet, a normal incisor relationship can only be achieved by proclining the lower incisors and retroclining the upper incisors. As a general rule, it is better not to do this, partly because the result frequently relapses, but mainly because the final appearance of the retroclined upper incisors is usually worse than the original condition.

In the second type of case, where the skeletal pattern is normal and the excessive overjet is caused by tilting of the labial segments, the musculature, both at rest and in action, should be examined and any abnormal sucking habits investigated. As a general rule, the lower incisors are rarely retroclined except by the mechanical action of a habit and only in these habit cases can the lower incisors be safely proclined without the risk of relapse. Then, with regard to the upper incisors, the most important decision to make is whether, if they are retroclined to a normal relationship to the upper apical base, they will come under the influence of the lower lip and be retained by it, despite any forward action of the tongue.

In the third type of case, which is commonly seen in practice, the causes are mixed. The lower apical base tends to be posteriorly related to the upper apical base and, in addition, the labial segments are tilted on their apical bases owing to the musculature or habits. It is difficult to be dogmatic about the treatment of these cases but, in practice, the following seems to be true:—

1. As a general rule, it is not possible to maintain an incisor relationship better than the skeletal pattern warrants. In other words, when the case has been completed and all retention has ceased, the incisor overjet and overbite usually remain excessive and reflect the postnormality of the skeletal pattern.

2. Again as a general rule, the lower incisors should not be proclined, unless they have been previously retroclined by the mechanical action of a habit. Otherwise they tend to relapse.

3. With regard to the upper incisors, the main thing to decide is whether, if they are retroclined to an average relationship to the upper apical base, they will come under the influence of the lower lip and be retained by it, despite any forward action of the tongue.

Retroclination of the Upper Labial Segment.—If it is decided that the upper labial segment can be retroclined and retained in a retroclined position, there are then two things to consider:—

1. *Incisor Overbite.*—The amount of the incisor overbite should be investigated. It may or may not be excessive and this may decide whether or not a bite plane will be required in the treatment.

2. *Extraction of Upper Teeth.*—It must be considered which upper teeth, if any, should be extracted in order to allow the upper labial segment to be retroclined. When making this decision, in addition to considering all the factors mentioned previously, one should also assess the severity of the Class II division 1 malocclusion and decide how much space is required in order that the upper incisors can be retroclined. In general, the severer types of Class II division 1 malocclusion require more space and one tends to extract more anteriorly. The less severe types require less space and one tends to extract more posteriorly in order to avoid spaces remaining in the anterior part of the mouth.

PRINCIPLES OF TREATMENT

After all the above factors have been carefully considered, then, and only then, is it possible to plan the treatment of a Class II division 1 malocclusion, and in practice the following principles have been found to be useful:—

Preservation of Tooth Tissue.—Whenever it is recognized that a case of Class II division 1 malocclusion will require treatment by appliances every effort is made to preserve the tooth tissue. It is particularly important to preserve the lower teeth. Early loss of lower deciduous teeth often results in collapse of

the lower arch, which complicates treatment, whilst loss of lower permanent teeth sometimes renders orthodontic treatment impossible.

Maintenance of Spaces.—In spite of all conservative efforts deciduous teeth are lost. When this occurs the spaces are watched and, if they show signs of closing, space maintainers are fitted. Again, special attention is paid to lower spaces in order to prevent collapse of the lower arch.

Opening of Lower Spaces.—However, many cases of Class II division 1 malocclusion are seen where lower spaces have closed. Under these circumstances it is usually necessary to open the lower spaces, unless their closure is great enough to be a sign of severe crowding requiring extraction of teeth from the lower arch.

Cessation of Sucking Habits.—There seems to be some difference of opinion about the importance of thumb- and finger-sucking as causes of malocclusion and there is some doubt whether they play a part in the aetiology of Class II division 1 malocclusion. However, there can be no argument that these habits should be stopped before any attempt is made to retrocline upper incisors. There is little to be gained in trying to retrocline upper incisors when, at the same time, the child is attempting to procline them by a thumb- or finger-sucking habit.

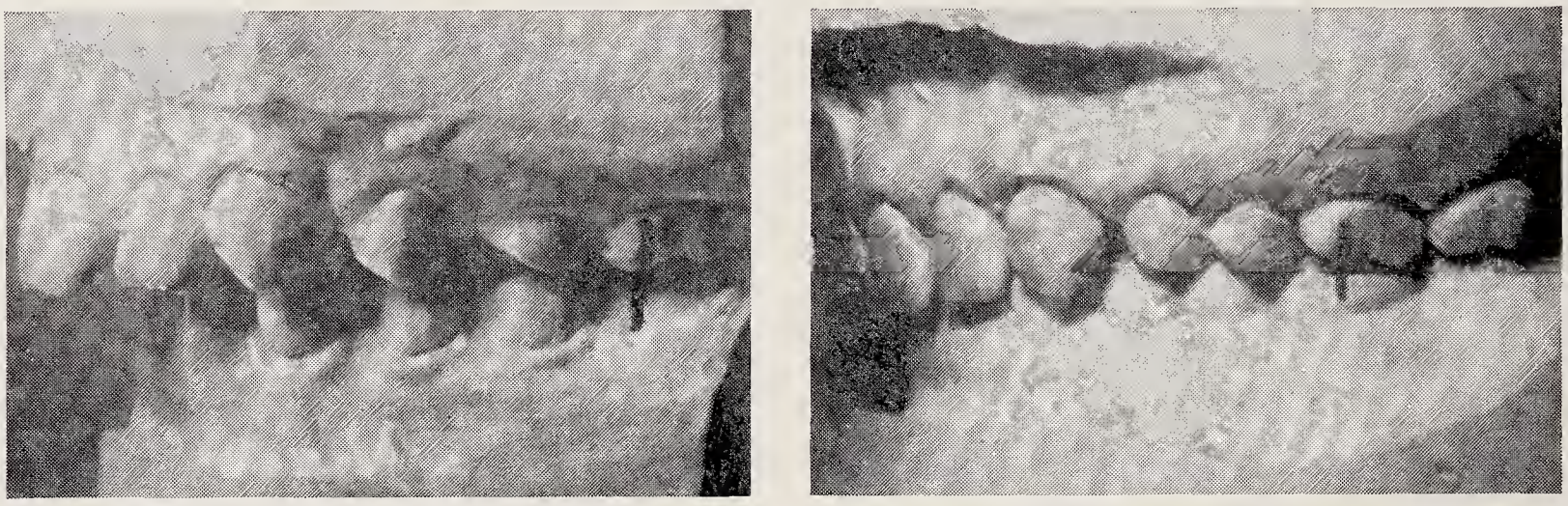
Treatment in the Deciduous Dentition.—As a general rule, it is found that effective and comprehensive treatment of a Class II division 1 malocclusion in the deciduous dentition is not possible. The measures mentioned previously, with regard to the preservation of tooth tissue, maintenance of spaces, opening of lower spaces, and cessation of sucking habits, are of course instituted. Apart from these, some improvement may be obtained if the child is provided with an oral screen, constructed to press on his upper incisors.

A B

Fig. 1.—A, Class II division 1 in mixed dentition with early loss of $\overline{|D}$. B, Result after treatment by lower space maintainer, serial extraction in upper arch and removable appliance to retrocline $\underline{21|12}$, followed by extraction of $\underline{4|4}$.

Treatment in the Mixed Dentition.—When the mixed dentition stage is reached, effective treatment of a Class II division 1 malocclusion is often possible. However, it is necessary to discuss whether treatment at this stage is indeed wise. On the one hand, it is very rightly pointed out that, after the incisor relationship has been corrected, a long period of retention over a number of years is usually required. Consequently, some authorities argue against the treatment of Class II division 1 malocclusion in the mixed dentition stage, preferring to wait until the permanent dentition is established. On the other hand, however, it must be emphasized that, because of the proclination of the upper labial segment, Class II division 1 malocclusion is a common predisposing factor in the fracture of upper incisors. Consequently, when treatment is delayed until the permanent dentition stage

has been reached, there is more risk to the upper incisors. On balance, it is surely better to face a long retention period than be obliged to treat a Class II division 1 malocclusion with the complication of fractured upper incisors. Therefore, whenever possible, treatment of Class II division 1 malocclusion is started in the mixed dentition stage.



A B

Fig. 2.—A, Tendency to Class II division 1 with spacing of teeth. B, Result after treatment by intermaxillary traction, using fixed appliances. No teeth were extracted.

In practice, it is usually found best to carry out serial extraction in the upper arch with retroclination of the upper incisors. First, the upper deciduous canines are extracted and, if necessary, a bite plane is fitted. Following this, the upper incisors are retroclined and, at a later date, it is often found necessary to extract the upper first premolars. Subsequently, of course, a long retention is usually required. *Fig.* 1 A, for example, shows models of a Class II division 1 malocclusion in the mixed dentition stage. There was a history of thumb-sucking, which had ceased, and there had been early loss of $\overline{|D}$. The lower arch was maintained by means of a lower space maintainer. Serial extraction in the upper arch was carried out and the upper incisors were retroclined by means of a removable appliance. Later, $\underline{4|4}$ were extracted and a long retention was necessary, using an oral screen. The result is shown in *Fig.* 1 B.

Treatment in the Permanent Dentition.—Treatment of Class II division 1 malocclusion in the permanent dentition may or may not involve the extraction of teeth and can be considered under the following headings:—

1. *Without Extractions.*—Treatment without extractions is usually indicated when the teeth are spaced. *Fig.* 2 A shows an example of a tendency to Class II division 1 malocclusion, with spacing of the teeth. Treatment was by means of intermaxillary traction, using fixed appliances, and no teeth were extracted. The result is shown in *Fig.* 2 B.

2. *Extraction of Upper Teeth.*—Many cases of Class II division 1 malocclusion require extraction of permanent teeth from the upper arch, in order that the upper labial segment may be retroclined. Any of the upper teeth may, of course, be selected for extraction, but the following principles are suggested:—

a. Central incisors: Upper central incisors are seldom extracted. Sometimes, however, they are badly fractured and must be removed and sometimes, of course, they are lost as a result of trauma. Under these circumstances, if there is crowding in the upper incisor region, a central incisor space may be utilized in order to retrocline the remaining incisors.

b. Lateral incisors: Extraction of upper lateral incisors is seldom indicated but, if they are absent, the spaces are, of course, utilized. Occasionally, however, when they are malformed or badly misplaced, they are extracted and the remaining upper incisors are retroclined.

c. Canines: Again, of course, when upper canines are absent, the spaces are utilized in order to retrocline the upper incisors. The only indications for extraction are when they are badly misplaced or severely rotated.

d. First premolars: The upper first premolars are probably the most popular teeth to

be selected for extraction in the treatment of Class II division 1 malocclusion. Nevertheless, it is well to realize that their extraction provides rather large spaces for the retroclination of the upper labial segment and should, therefore, be reserved for the treatment of severer types of Class II division 1 malocclusion. For example, *Fig.* 3 A shows a severe type of Class II division 1 malocclusion. There was a large incisor overjet and the lower arch was distal to the upper arch to the extent of the full width of a premolar. The case was treated by extraction of $\frac{4|4}{}$ followed by intermaxillary traction, using fixed appliances, and the result obtained is shown in *Fig.* 3 B. Small spaces remained distal to $\frac{3|3}{}$, but these are, of course, a common occurrence after the extraction of $\frac{4|4}{}$.

e. Second premolars: When upper second premolars are absent their spaces are utilized in treatment, and extraction of upper second premolars is indicated when they are badly misplaced palatally. Otherwise their extraction is usually restricted to the milder types of Class II division 1 malocclusion, where less space is required for the retroclination of the upper labial segment. *Fig.* 3 C shows an example of such a condition. There was a tendency to Class II division 1 malocclusion and if $\frac{4|4}{}$ had been extracted, it would have been necessary to move $\frac{65|56}{}$ mesially as well as $\frac{321|123}{}$ distally. Therefore, in this case, $\frac{5|5}{}$ were extracted. Following this, $\frac{4|4}{}$ were moved distally and the upper incisors retroclined, all by means of removable appliances.

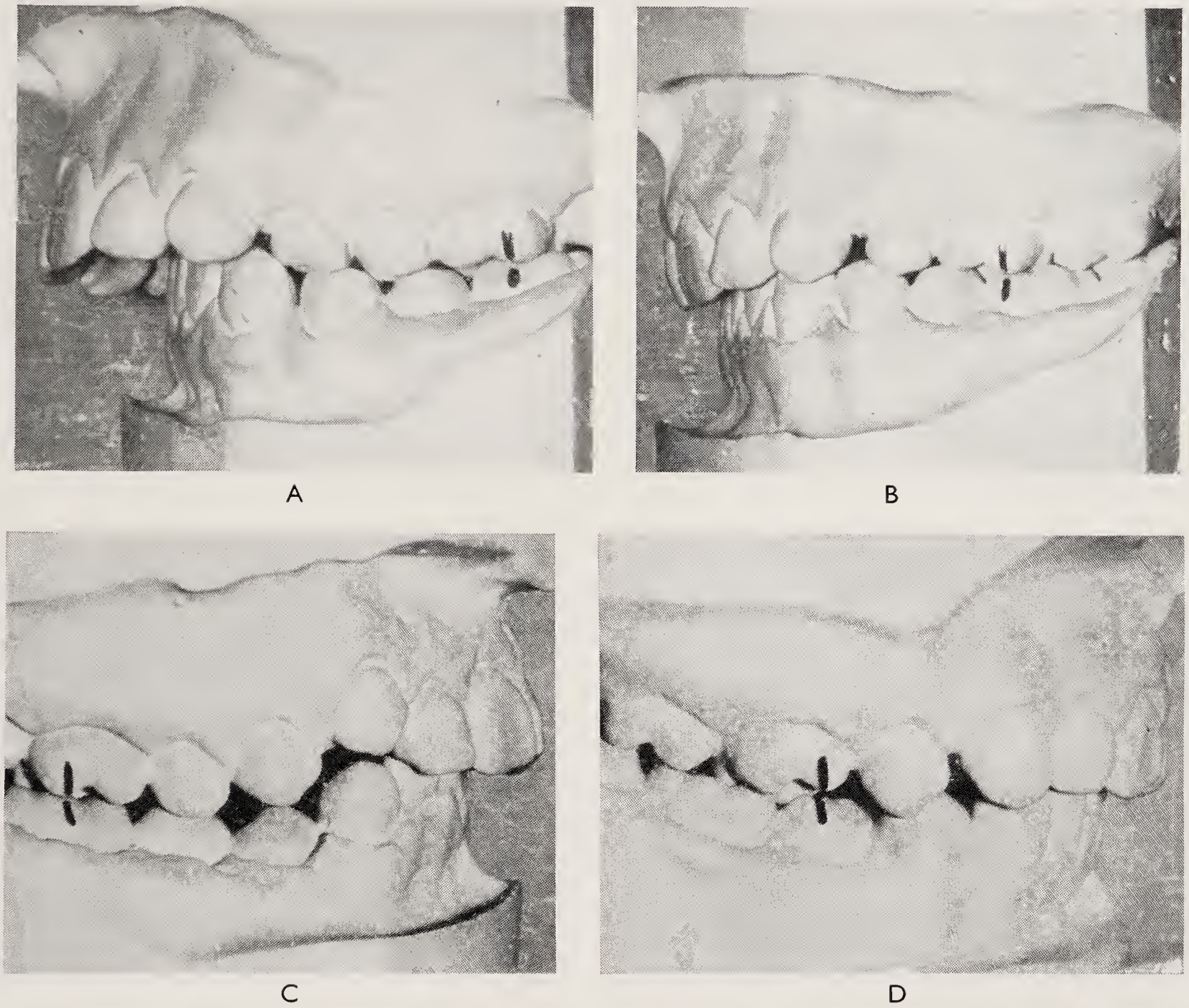
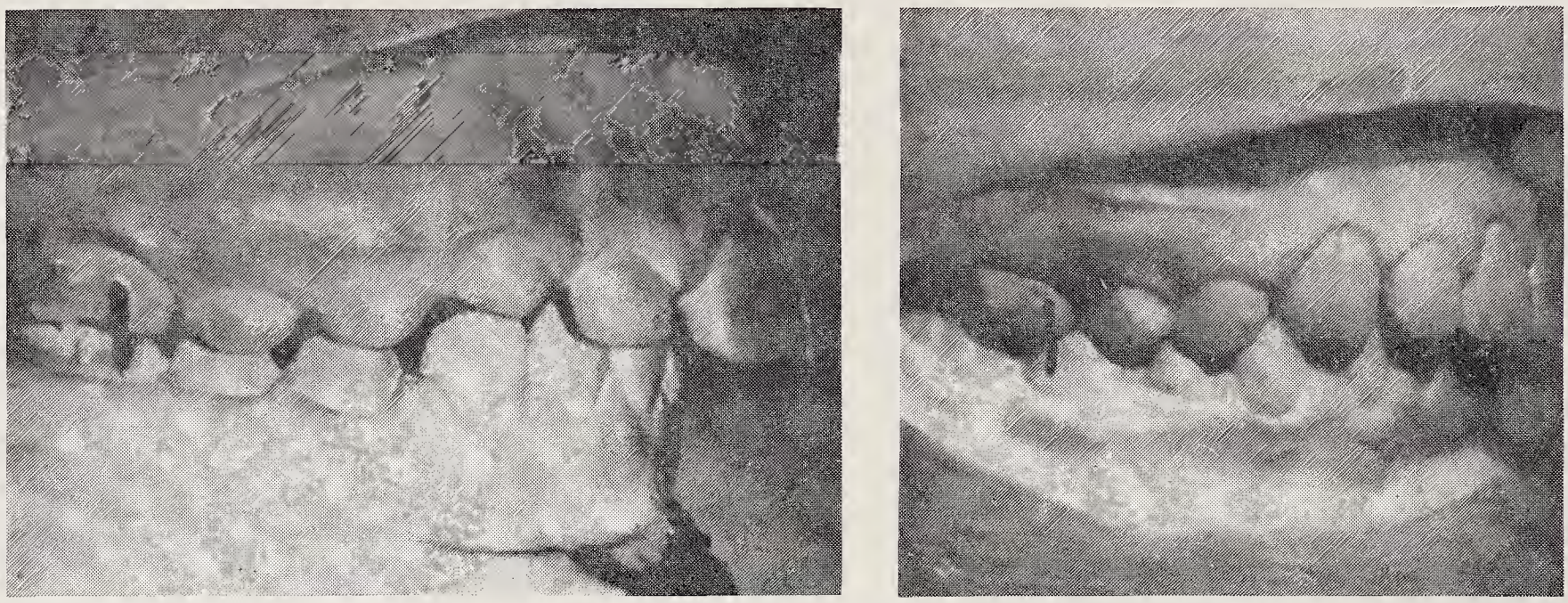


Fig. 3.—A, Severe Class II division 1 with large incisor overjet and lower arch a full premolar width distal to upper arch. B, Result after extraction of $\frac{4|4}{}$ and treatment by intermaxillary traction, using fixed appliances. C, Tendency to Class II division 1 with lower arch only half a premolar width distal to upper arch. D, Result after extraction of $\frac{5|5}{}$ and treatment by removable appliances to move $\frac{4|4}{}$ distally and retrocline $\frac{321|123}{}$.

The result which was obtained is shown in *Fig.* 3 D.

f. First molars: Upper first molars are, of course, extracted when they are very carious, but it is better if their extraction can be restricted to the milder types of Class II division 1 malocclusion. If they are extracted in a severe Class II division 1 case, one is faced with rather lengthy orthodontic treatment to move the premolars distally and retrocline the upper labial segment. *Fig.* 4 A shows a case where there was a tendency to Class II division 1 malocclusion. $\frac{6|6}{}$ were very carious. Treatment was to extract $\frac{6|6}{}$ and carry out intermaxillary traction, using fixed appliances. The result is shown in *Fig.* 4 B. It is interesting to note the good contact point relationship between $\frac{7|}{}$ and $\frac{5|}{}$.

g. Second molars: Extraction of upper second molars is indicated in milder types of Class II division 1 malocclusion, but is usually reserved for those cases where upper third molars are present. For example, *Fig.* 4 C shows models of a case which had a tendency to Class II division 1 malocclusion and radiographs revealed that $\frac{8|8}{}$ were both present. Treatment was to extract $\frac{7|7}{}$ and move the upper buccal segments distally by means of a removable appliance. Following this, an oral screen was used and the result is shown in *Fig.* 4 D.



A B C D

Fig. 4.—A, Tendency to Class II division 1 with $\frac{6|6}{}$ very carious. B, Result after extraction of $\frac{6|6}{}$ and treatment by intermaxillary traction, using fixed appliances. C, Tendency to Class II division 1. D, Result after extraction of $\frac{7|7}{}$ and treatment by removable appliance to move upper buccal segments distally, followed by oral screen.

3. *Extraction of Lower Teeth.*—When the lower arch is crowded in Class II division 1

malocclusion it may be necessary to extract lower permanent teeth. Any of the lower permanent teeth may, of course, be selected for extraction, but the following principles are suggested:—

a. Incisors: When there is crowding in the lower incisor region, but no crowding in the lower buccal segments, extraction of a lower incisor is often indicated and is frequently

A

B

C

D

Fig. 5.—A, Class II division 1 with loss of $\underline{4|4}$. No crowding in lower buccal segments. B, Anterior view showing crowding of upper and lower incisors. $\overline{1|1}$ tilted to right and $\overline{3|}$ partly blocked out. C, Result after extraction of $\overline{1|}$ and treatment by fixed appliance to move $\overline{2|}$ mesially and $\overline{3|}$ lingually, followed by intermaxillary traction, using fixed appliances with twin arch. D, Intra-oral view of result.

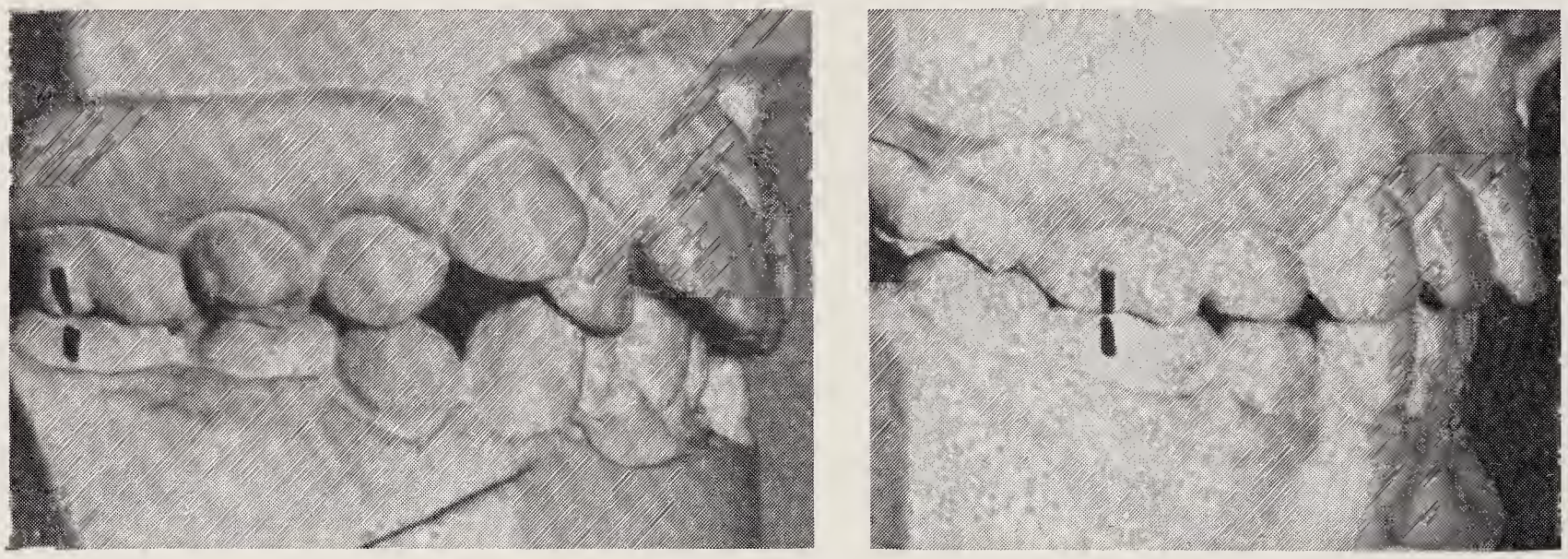
combined with extraction of the upper first premolars. An example is shown in *Fig.* 5. There was a Class II division 1 malocclusion with loss of $\underline{4|4}$. In *Fig.* 5 A it will be noticed that there was no crowding in the lower buccal segments, but in *Fig.* 5 B it will be seen that both the upper and lower incisors were crowded. $\overline{1|1}$ had tilted to the right and $\overline{3|}$ was partly blocked out. Treatment in the lower arch was to extract $\overline{1|}$ and then move $\overline{2|}$ mesially and $\overline{3|}$ lingually by a fixed appliance. Following this, intermaxillary traction with a twin arch was used in order to retrocline the upper incisors and correct their imbrication. The result obtained is shown in *Fig.* 5 C, D.

b. Canines: Lower canines are extracted when they are completely blocked out vertically.

c. First premolars: Extraction of lower first premolars is indicated when there is crowding in the lower buccal segments with the lower canines proclined. Usually the extraction of lower first premolars is combined with the extraction of upper first premolars. An example is shown in *Fig.* 6 A. There was a tendency to Class II division 1 malocclusion together with crowding in both arches and proclination of $\frac{3|3}{\overline{3|3}}$. Treatment was to extract $\frac{4|4}{\underline{4|4}}$ and retrocline $\frac{3|3}{\overline{3|3}}$ by means of fixed

appliances. Following this, intermaxillary traction was carried out with the extraction of $\underline{7|7}$. The result is shown in *Fig.* 6 B and it is interesting to note the good contact point relationship between $\underline{8|}$ and $\underline{6|}$.

d. Second premolars: Lower second premolars are extracted when there is crowding in the lower buccal segments with forward movement of lower first permanent molars, but with the lower canines not proclined. For example, *Fig.* 7 A shows a severe Class II division 1 malocclusion. There was crowding in the lower buccal segments with forward movement of $\overline{6|6}$, blocking out $\overline{5|5}$, but $\overline{3|3}$ were not proclined. Treatment was to extract $\overline{5|5}$ and then, because the Class II division 1 malocclusion was severe, $\underline{4|4}$ were extracted in order to provide adequate spaces for the retroclination of the upper labial segment. Intermaxillary traction, using fixed appliances, was carried out and the result of the treatment is shown in *Fig.* 7 B. *Fig.* 7 C shows another example, but in this case the Class II division 1 malocclusion was only mild. Again, there was crowding in the lower buccal segments with forward movement of $\overline{6|6}$, blocking out $\overline{5|5}$, but $\overline{3|3}$ were not proclined. Treatment again was to extract $\overline{5|5}$. However, in this case, it was felt that, because the malocclusion was only mildly Class II division 1, extraction of $\underline{4|4}$ would provide more space than was necessary for the retroclination of the upper labial segment and would probably leave ugly gaps distal to $\underline{3|3}$. Consequently, $\underline{5|5}$ were extracted and $\underline{4|4}$ moved distally by means of a removable appliance. Following this, the upper incisors were retroclined by means of a further removable appliance and the result obtained is shown in *Fig.* 7 D.



A B

Fig. 6.—A, Tendency to Class II division 1 with crowding in both arches and proclination of $\frac{3|3}{3|3}$. B, Result after extraction of $\frac{4|4}{4|4}$ and treatment by fixed appliances to retrocline $\frac{3|3}{3|3}$, followed by extraction of $\underline{7|7}$ and intermaxillary traction, using fixed appliances.

e. First molars: Lower first molars are only extracted when they are very carious or badly decalcified. When one is obliged to extract lower first molars it is almost invariably necessary to extract the upper first molars also. *Fig.* 8 A, for example, shows a Class II division 1 malocclusion with loss of $\overline{6|6}$. Treatment was to extract $\underline{6|6}$ and the malocclusion was corrected by means of an Andresen appliance followed by an oral screen. The result obtained is shown in *Fig.* 8 B.

Retention.—After the active treatment of a Class II division 1 malocclusion has been completed, retention is nearly always necessary. The relapse which is most liable to occur is for the upper incisors to procline. Consequently, retention is directed towards maintaining the labial segment relationship which has been achieved. There are a variety of methods and appliances which can be used but, in practice, the following procedures have been found to be effective:—

1. An attempt is made to educate the child to keep his lips together and he is encouraged to develop, as much as possible, his conscious

A

B

C

D

Fig. 7.—A, Severe Class II division 1 with crowding in lower buccal segments. There was forward movement of $\overline{6|6}$, blocking out $\overline{5|5}$, but $\overline{3|3}$ were not proclined. B, Result after extraction of $\frac{4|4}{5|5}$ and treatment by intermaxillary traction, using fixed appliances. C, Tendency to Class II division 1 with crowding in lower buccal segments. There was forward movement of $\overline{6|6}$, blocking out $\overline{5|5}$, but $\overline{3|3}$ were not proclined. D, Result after extraction of $\frac{5|5}{5|5}$ and treatment by removable appliances to move $\underline{4|4}$ distally and retrocline $\underline{321|123}$.

A

B

Fig. 8.—A, Class II division 1 with loss of $\overline{6|6}$. B, Result after extraction of $\underline{6|6}$ and treatment by Andresen appliance and oral screen.

control over his lip musculature. To this end, the will of the child is activated. In the case of a girl, an appeal is made to her vanity and to her sense of wanting to have a good appearance. It is explained to her that she looks much better with her lips together and that, if she fails to keep them together, her upper incisors are liable to become prominent again and give her a poor appearance. In the case of a boy, an appeal to his vanity is of little use because, at the time when treatment is usually completed, a boy is not particularly interested in his appearance. Frequently, however, it has been found that an appeal to a boy's sense of wanting to be physically efficient and "tough" is sufficient to activate his will.

2. When fixed appliances are used to correct a Class II division 1 malocclusion, they are removed as soon as the required labial segment relationship has been obtained. Then, within twenty-four hours, the child is fitted with an upper removable appliance, carrying a labial bow and a passive inclined plane, in order to retain the incisor relationship. This appliance is worn continually day and night, for at least six months. Then, an oral screen is constructed and gradually substituted for the upper removable appliance. The substitution is usually effected in this manner. The upper appliance is worn during all the day and the screen is worn for one hour in the evenings and also all night and every night. When the screen is being worn the upper appliance is, of course, removed. When the child becomes fully competent with the screen, he ceases wearing the upper appliance during the day but continues using the screen for one hour in the evenings and all night and every night. In addition, it has been found an advantage to fit a removable wire loop to the screen in order that it can be used to exercise the lips. This method of exercising the lips seems to increase the child's conscious control over them and, in practice, proves more effective than prescribing lip exercises.

3. When a Class II division 1 malocclusion is treated with removable appliances, the final tooth movement is usually to retrocline the upper incisors by means of an appliance with a labial spring. When the desired labial segment relationship has been achieved, the labial spring is rendered passive and an oral screen constructed. Then, a gradual change to the oral screen is carried out in the same manner as described previously. Again the screen usually carries a removable wire loop in order that it may be used as an exerciser.

4. The child continues to wear the oral screen for one hour in the evenings as well as all night and every night and, in addition, he is encouraged to use the screen with the wire loop, as much as possible, in order to exercise his lips. These methods are continued until it is judged that all possible lip control has been developed. Then, the oral screen is gradually withdrawn, the exercises being ceased last.

Finally, although in this paper an attempt has been made to consider the treatment of Class II division 1 malocclusion, I think it is well to emphasize that the treatment of Class II division 1 malocclusion cannot be dissociated from the general treatment of a child's mouth. Nor, indeed, is it possible to consider the treatment of a child's mouth without considering the child himself. Sometimes, I feel, we orthodontists tend to be overspecialized and we run the danger of regarding a child's mouth as a problem in malocclusion. We are apt to forget that, fundamentally, it is a child's mouth we are dealing with and that, moreover, the mouth is only a part of the child.

That famous Newcastle upon Tyne pædiatrician, the late Sir James Spence, concluded one of his papers with these words: "It must be remembered that there are no such things as diseases but only human beings suffering from disease." May I, on a much humbler plane, conclude with these words: "It must be remembered that there are no such things as Class II division 1 malocclusions but only children suffering from Class II division 1 malocclusion."

Acknowledgements.—I would like to express my grateful thanks to Mr. A. J. Finlayson, A.I.B.P., for the photography, and to the Photographic Department of the Newcastle upon Tyne Dental Hospital for permission to reproduce the illustrations.

DISCUSSION

The Chairman (Professor G. E. M. Hallett) said as there were places where tooth quality was rather poor the orthodontist did have to cut his suit according to his cloth and very often the cloth was not very good and was small in quantity, and one of their main problems was to go through all the possible permutations of possible extractions and try to find out the best one. Mr. Littlefield had put that forward splendidly in his paper.

Mr. Wilson, congratulating Mr. Littlefield on his excellent paper, said he had certainly got his feet on the ground. So often they heard a very scientific paper which seemed to take them away from the actual practice of orthodontics, but Mr. Littlefield had very sensibly and successfully brought them back and included factors seldom referred to in journals and text-books—environment and distance to travel.

There was a very narrow approach to the question of extraction which would not admit of extractions in the anterior segment. He shared Mr. Littlefield's opinion that this was wrong. His own view was that one had to consider every tooth as a potential one for extraction and not only the first premolars.

In one case Mr. Littlefield had treated a Class II with bimaxillary crowding by extraction of lower first premolars and intermaxillary traction, which Mr. Wilson said might have been treated by extracting the lower second premolars, because in his experience crowding of the incisors was reduced and incisal relationship corrected by extraction of upper first and lower second premolars. In another case Mr. Littlefield had taken out upper second molars and the third molars came nicely into position but he did not mention the lower third molar; it would be interesting to know what he had done there: did he wait until it came through and then extract it or leave it alone? It was almost certain to traumatize the gum behind the upper third molar.

Mr. Littlefield, in reply to Mr. Wilson, said he would only extract lower first premolars and retract lower canines when the lower arch was crowded and the lower canines were proclined. In the case he had shown he felt that, if he had extracted the lower second premolars, the treatment would have been unduly prolonged.

Referring to the case where he had extracted the upper second permanent molars and the upper third molars had come into good alinement, he was, of course, aware of the possibility of impaction of the lower third molars. With regard to the problem of third molars in crowded lower arches, there were, as he saw it, three alternatives. Either the third molar tooth germs could be removed early, or other teeth could be extracted to allow the third molars to erupt, or the third molars could be extracted at a later age if they became impacted. Usually he preferred to adopt the last alternative. He would certainly hesitate to extract lower second permanent molars from a good regular lower arch and risk a poor alinement of third molars.

Mr. Trevor Johnson said he had been very pleased to hear Mr. Littlefield's paper because it was so much to his own way of thinking. There was one point which he wished to raise, concerning one of the last cases shown by Mr. Littlefield, where he had taken out a lower central incisor and two upper fours, and there was slight imbrication of the upper incisors with no closed bite. His own view was that rather than put on a twin-wire arch and intermaxillary traction he would have left that case as it was or treated it still further with a simple appliance and possibly with slight lingual movement of the upper incisors if necessary.

Like Mr. Littlefield, he laid particular stress on keeping the lower arch at the maximum possible size in Class II cases, and quite often, where the arrangement of canines was satisfactory and not leaning forwards, as Mr. Littlefield had spoken of, he would prefer to take out an incisor to relieve the lower teeth and possibly regain space, too, if necessary. He felt sure it was very much better to take out a lower incisor in certain cases than to take out two premolars.

Mr. Littlefield, in reply to Mr. Trevor Johnson, said he had purposely refrained from showing appliances partly from lack of time but mainly because he believed they were only of secondary importance. As he saw it, diagnosis and treatment planning were the most important considerations and appliances were relatively unimportant. Appliances, moreover, were very much a matter of individual choice. For example, referring to imbricated incisors, he had found he could correct these most easily with a twin arch which was, of course, the reason he used a twin arch for imbricated incisors.

With regard to the extraction of lower teeth, he would extract a lower incisor in mild degrees of crowding and lower canines when they were completely blocked out. He would extract lower first premolars when there was crowding in the lower buccal segments with the lower canines proclined. Lower second premolars were extracted when they were blocked out by forward movement of lower first permanent molars but when the remaining teeth were in good alinement.

Mr. Watkin asked whether Mr. Littlefield X-rayed the eights before dismissing a patient. One saw so much trouble in later life with impacted eights because they were not X-rayed at the right time. He personally made a definite rule to X-ray the eights at about 14 years of age. About twenty-five years ago he had a case which finished very nicely with the teeth all lined up straight, with the exception of one imbricated lower incisor. In those days he was induced to take the patient's lower incisor out, and about two years later she came back with the upper incisors imbricated, and he would have done anything in the world to put that lower incisor back. It took at least two premolars in the upper jaw to balance one lower incisor.

He knew it was quite usual to take out fours but he would like to be much more sure that it was the right thing to do, and as a rule he believed that fives were very much better than the fours. Why did everybody insist that the poor old four had to go? Every time it was just as easy to take the five out and thereby insure that no space would be left behind the three.

Mr. Littlefield, in reply to Mr. Watkin, said he had full mouth radiographs of every case before planning treatment. He was always aware of the third molar problem but, unfortunately, at the time when treatment was usually commenced, it was impossible to decide if they would be impacted. Fundamentally, the possibility of their impaction depended on the relationship of the size of tooth tissue to the size to which the apical bases would grow. In practice, this was a most difficult factor to assess.

With regard to the extraction of lower incisors, although he had shown a case where he had extracted a lower incisor, it was not commonly done. If there was

any possibility of the lower arch collapsing, he preferred to leave it even if it was crowded.

With regard to the extraction of upper first premolars, he thought that the main indication for their removal was a severe Class II division 1 malocclusion when a large amount of space was required for the retroclination of the upper labial segment. He was very much aware of the defect of spaces remaining distal to the upper canines after upper first premolars had been extracted.

Mr. Miller said he would like to change just one word on the question of the extraction of incisors: he would say that one must consider not the extraction of *a* lower incisor but *the* lower incisor, and pick the case in which it could be done. If the two lower centrals were straight and one of these straight ones was taken out one was just as mueh in trouble when it was finished.

Mr. Littlefield, in reply to Mr. Miller, said he, too, had great difficulty in deciding which lower incisor should be extraeted. He agreed that it was important to study the axial inelination of the lower incisors and their labiolingual position together with their quality.

Miss Weyman said that during the morning a lot had been heard about the spaee left behind the upper canines when extracting the first premolars. In her youth she had been the subject of the extraetion of first premolars and had a spaee about 3 mm., but she doubted whether anyone had ever notieed it unless she had pointed it out, and she was certainly not conscious of it.

Mr. Breakspear said he, too, had found Mr. Littlefield very refreshing, but he disagreed when he referred to severe cases and the final appearanee of retro-inclined upper incisors. The orthodontist might be conscious of that, but he had very rarely heard patients complain of it; they were much more conscious of them when they projected. His own most severe Class II case had been completed and had just got married, and he believed her husband did not look so much from the side but was more interested in the front view!

The patient's consciousness of appearance was coming more and more to the fore in these days of films and television, and he wondered whether anyonc had yet found that patients did not want to have their lips together, because it seemed to be more and more the tendency for film stars to be photographed with their lips parted.

Mr. Littlefield, in reply to Mr. Breakspear, said that, with regard to the poor appearance of upper incisors after they had been retroclined, he was referring to the type of case where the sole cause of the labial segment relationship was the fact that the lower apical base was posteriorly related to the upper apical base. In this type of case, if the upper ineisors were retroclined to meet the lower incisors, the final appearance was often "gummy" and, consequently, worse than the original appearanee. Also, of course, such retroclined upper incisors tended to relapse.

The Chairman (Professor G. E. M. Hallett) said there had been many valuable comments on the paper, which dealt with a subjcct on which they must all have their own ideas. Where Mr. Littlefield had taken first premolars, he himself might have taken second premolars and another person might have taken something else, but he had worked with Mr. Littlefield for a long time and he was producing in Newcastle some very fine and durable results in the great majority of his cases.

III. TREATED CASES

(*Short Communications*)

By **A. C. CAMPBELL**, B.D.S., F.D.S. R.C.S., M.R.C.S., L.R.C.P., D.Orth. R.C.S., and
J. S. ROSE, B.D.S., F.D.S., D.Orth. R.C.S.

(*A. C. Campbell*)

Case 1.—The first case (J. B.) is an Angle's Class II division 1 type on a virtually normal skeletal base, where the malocclusion has resulted from the abnormal axial inclinations of the teeth. The method used to assess the skeletal relationship was to place the head in the position of the erect posture with the Frankfort Plane horizontal, and the relative positions of the incisor apices were noted.

At the age of 8 years 2 months the occlusion showed an anterior open-bite, and a cross-bite on the right side. A right thumb-sucking habit was still present. At rest the lips were parted by the upper incisors, but there did not appear to be a "tongue-lip" resting posture although there was perhaps the slightest suspicion of a lisp. It was difficult to make an assessment of the normality of the

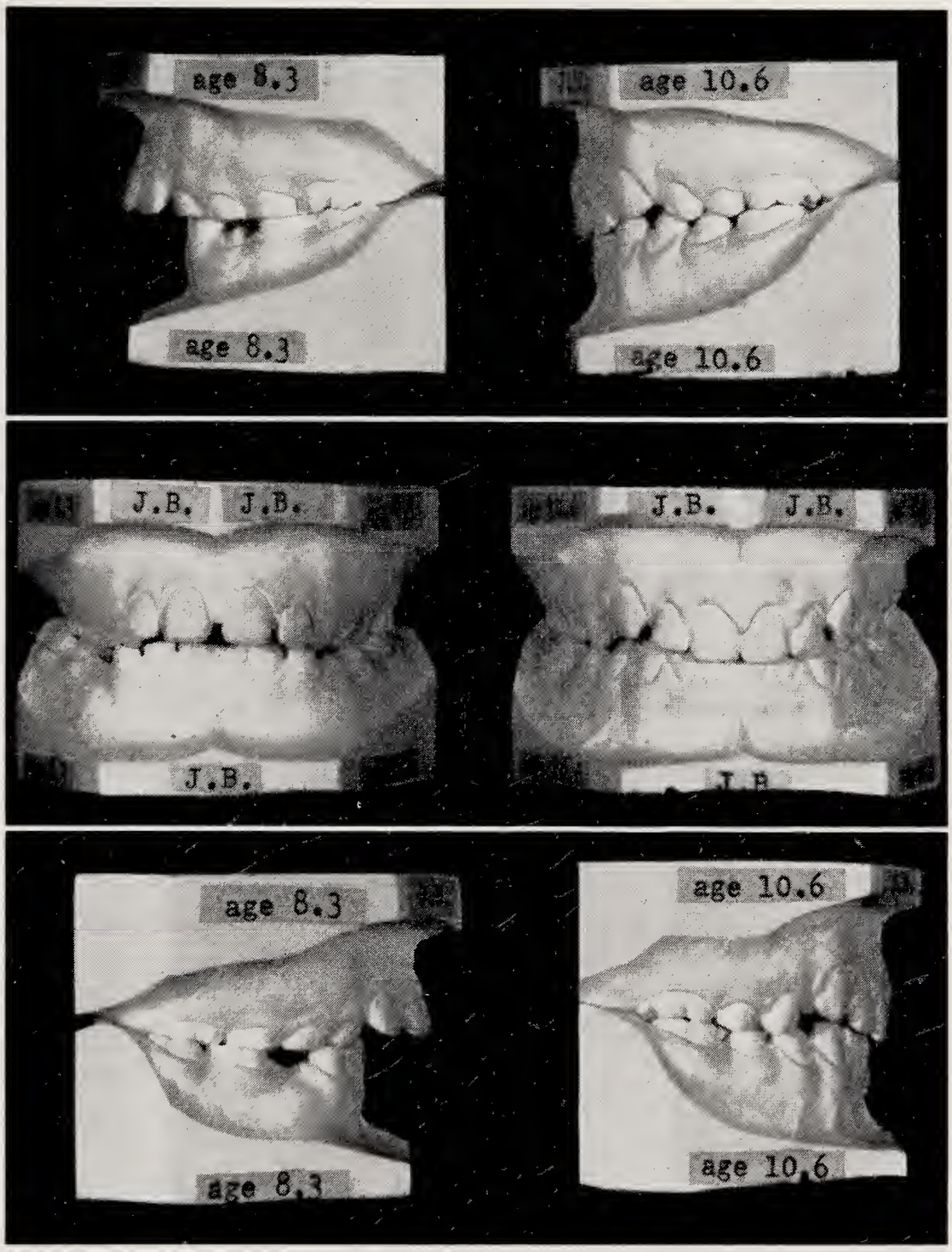


Fig. 1.

oromuscular behaviour. I thought that at the mylohyoid phase of swallowing the cheek teeth were brought into contact; thus I accepted the tongue thrust, which was then apparent, as secondary to the anterior open-bite. This I believed to be caused by the persistent thumb-sucking habit.

occlusal relationships can be seen. It will be noted that $\underline{3|3}$ have not yet fully erupted.

Following treatment there is now no lisp, and it is readily seen that the teeth are placed in occlusion at the mylohyoid phase of swallowing—this seems to me to confirm my original assumption that the oromuscular

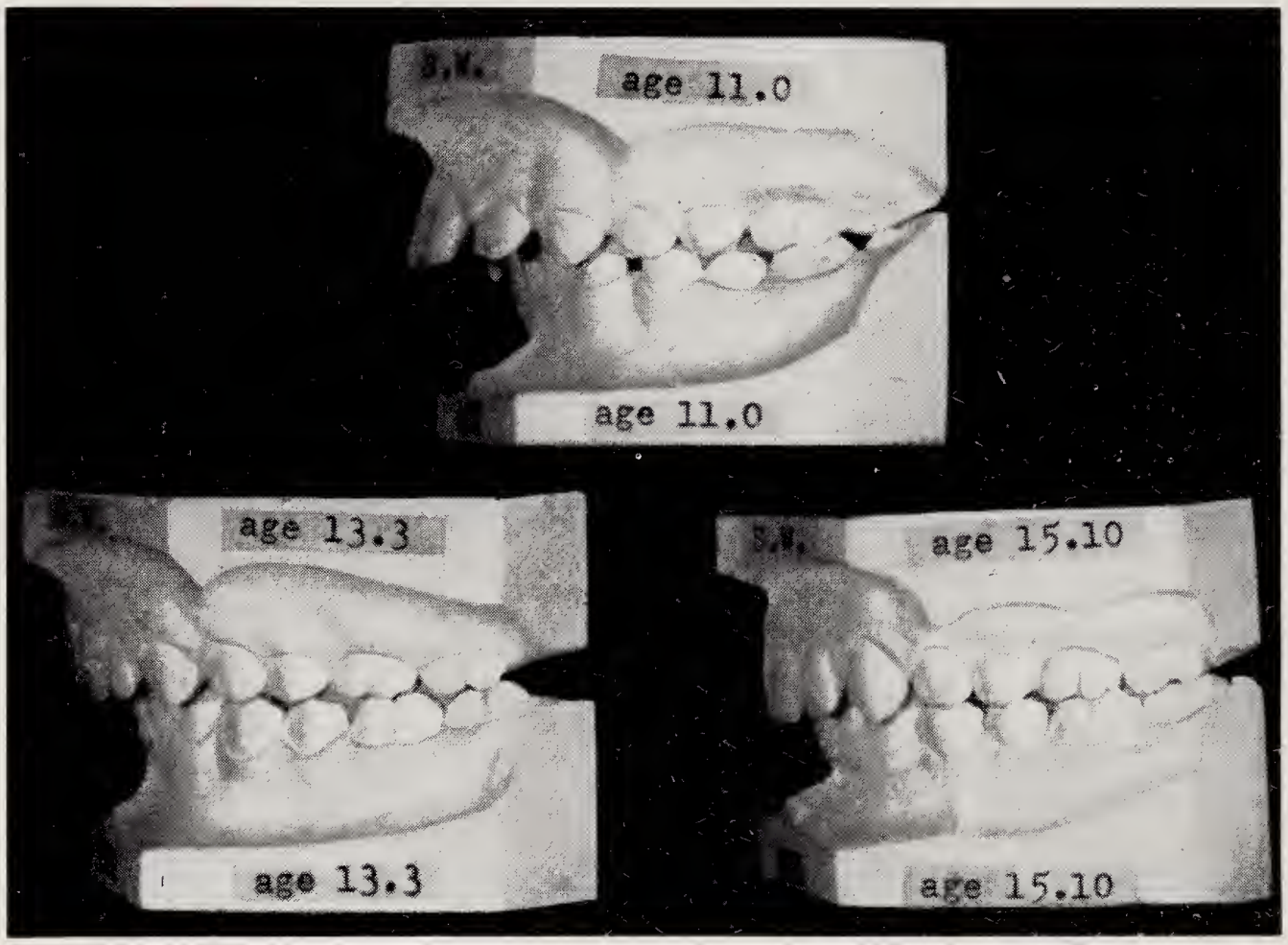


Fig. 2.

It seemed to me that in view of the basically normal soft-tissue behaviour and the normal skeletal pattern the malocclusion should be corrected by expansion of the upper dental arch. This is followed by correction of the axial inclinations of the teeth with simple reciprocal intermaxillary traction with a monobloc.

This plan of treatment was carried out—the expansion plate also serving to inhibit the habit. The upper dental arch was deliberately over-expanded and the relapse which occurred after the discontinuation of treatment with the screw plate was directed by facets cut on the monobloc to assist in the distal tilting of the upper cheek teeth. The monobloc used was a simple type with no auxiliaries at all. A monobloc retainer is now being worn sporadically.

The occlusion is shown (*Fig.* 1) before and after treatment and the change in behaviour was normal and that the tongue-thrust was a secondary one.

This case has been shown as it is felt that simple reciprocal intermaxillary forces should essentially only be used without extractions in the upper dental arch where the skeletal base is normal or virtually normal, and where the malocclusion of the Class II division 1 type has been produced by altered axial inclinations. That is to say these forces should be used where reciprocal tilting is required in both arches to produce the hypothetical normal axial inclinations, and where these hypothetical inclinations will lead to a satisfactory and stable incisor relationship. It is suggested that the simple application of such forces without extractions is not suitable where such hypothetical inclinations will not produce a stable incisor relationship, as for example where there is a more marked skeletal postnormality.

Case 2.—The second case (S. W.) is quite different in that there is a skeletal 2 relationship, and the lower arch is deficient in that $\overline{5}|$ is missing. This case has been treated without upper extractions, and marked proclination of the lower incisors compensates for some of the skeletal deformity.

In this case there was a history of thumb-sucking up to the age of 7 years. At rest the lips were parted by the upper incisors as would be expected with this skeletal relationship. On swallowing, the cheek teeth were brought into contact, and there was no tongue thrust. Thus I took the oromuscular behaviour

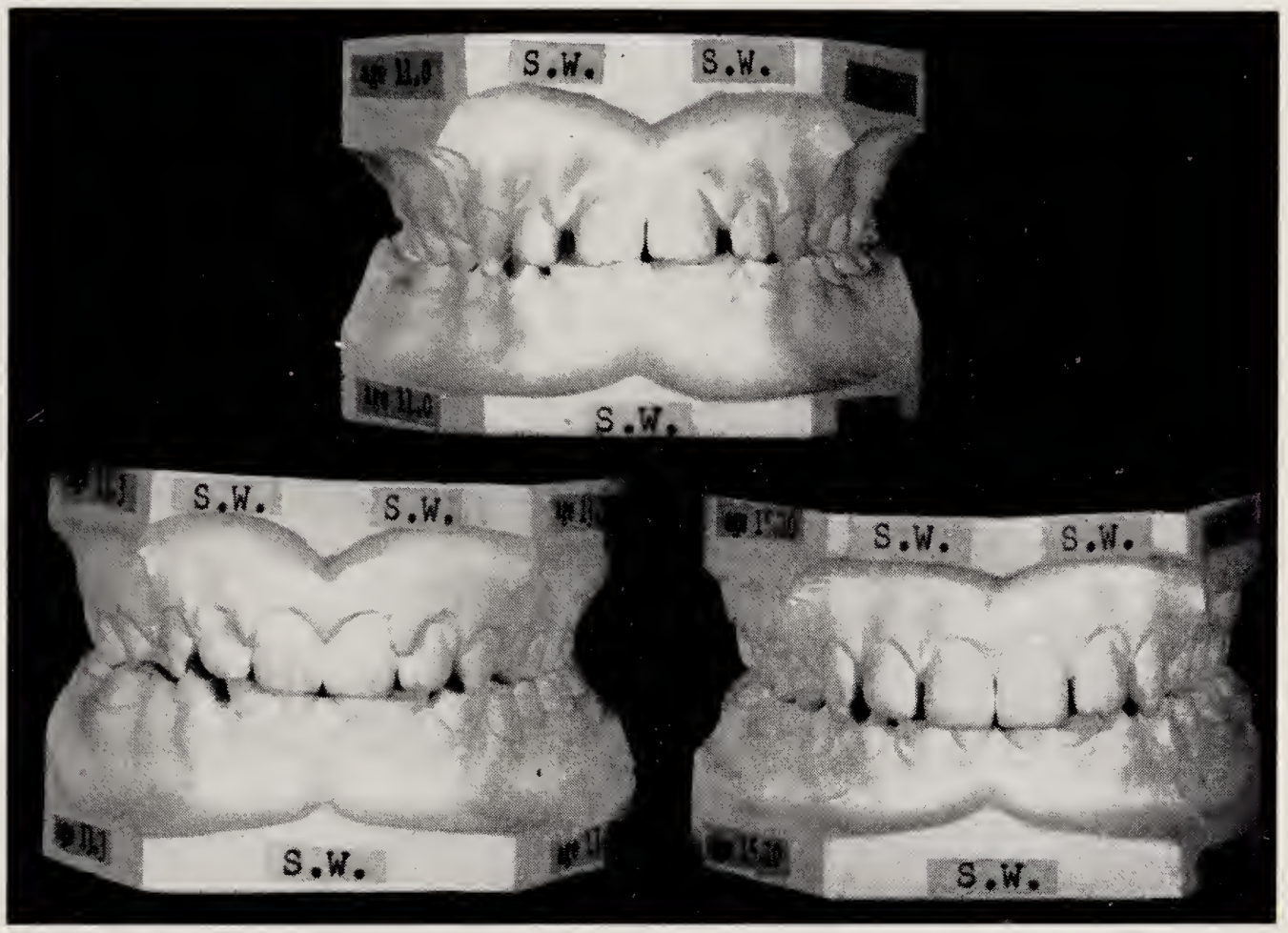


Fig. 3.

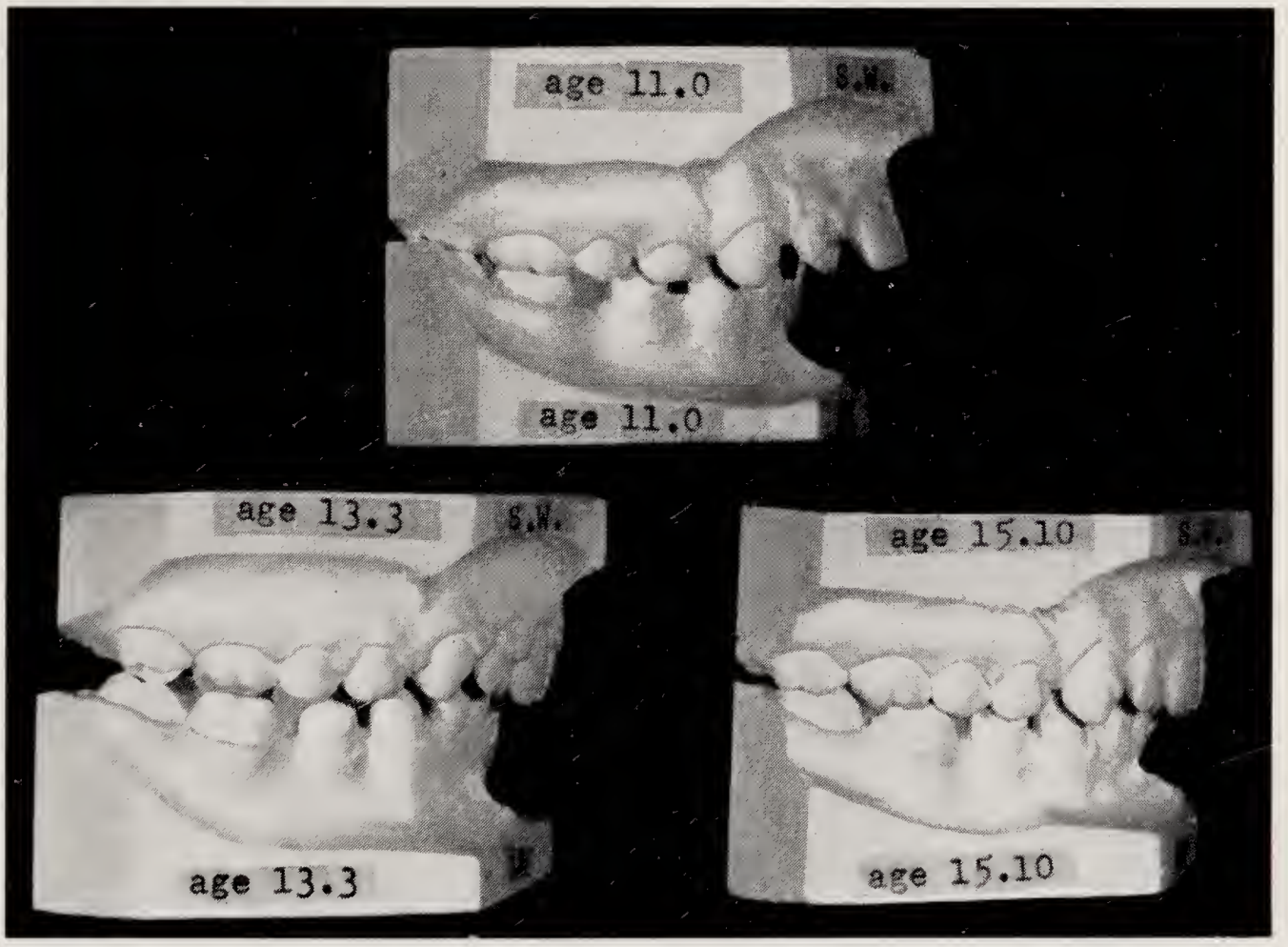


Fig. 4.

to be normal in that it possessed the common denominator of normality (the bringing into contact of the cheek teeth at the mylohyoid phase of swallowing). The fact that the lips were parted by the upper incisors at rest and in activity does not represent an abnormality

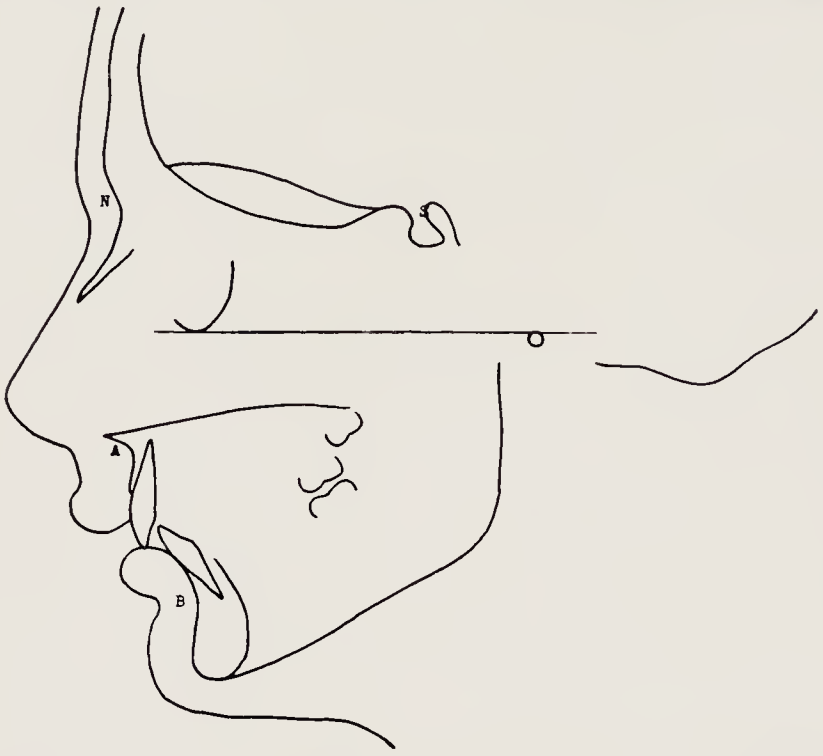


Fig. 5.—Tracing from lateral radiograph at rest. At the end of active treatment.

of the basic behaviour, but a variation of the accessory features necessitated by the skeletal relationship.

Treatment advised in this hospital case was: "Monobloc to start with; review re upper extractions." A monobloc was used for nearly a year—every effort being made to reduce the effects of reciprocal forces on the lower dental arch. Some progress was made but it was slow, and in view of the ever increasing probability of the undesirable effects becoming apparent in the lower arch, it was decided to change from a monobloc to a simple upper plate to retract the upper incisors within the space available without employing extractions. Slides (*Figs.* 2, 3, and 4) show the occlusion before treatment, at the end of active treatment, and one year after all retention had ceased. No lateral radiographs are available of the condition before treatment, but I wish to show a tracing of one taken at rest at the end of active treatment (*Fig.* 5). This shows the extreme proclination of the lower incisors and also the position of the lips in relation to the upper incisors. The next slide (*Fig.* 6) shows a tracing from a film —at the time of the last models—taken at the mylohyoid phase of swallowing, when some barium paste had been given to the patient. This emphasizes the normality if the soft-tissue behaviour for the height of the lip line is shown, and the position of the

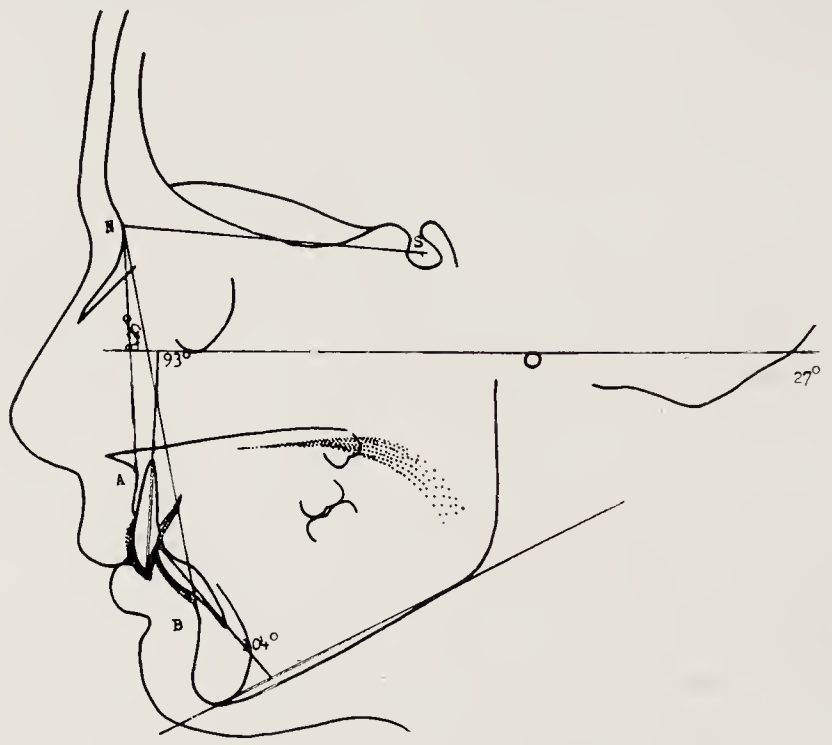


Fig. 6.—Tracing from lateral radiograph at "mylohyoid phase" of swallowing with barium paste.

tongue tip is also seen to be placed lingual to the lower incisors.

It seemed to me that this would be of interest because it illustrates that a case with a marked skeletal deformity could be treated without recourse to extractions in the upper arch, even though one unit was missing in the lower arch. It will be noted that after treatment the SNA/SNB difference is 8·25°. It is also of interest to note that a proclination of the lower incisors to the extent of 104° is a factor in compensating for the skeletal deformity. I do not wish to propose, however, that proclination of this order should be contemplated as a specific part of a treatment plan, for that would be doomed to failure in most instances. The saving grace here was that this proclination was present naturally before treatment, and the questions to be posed are: "Why was this so?" and "Why has it been maintained?" I would suggest that the answer is that the oromuscular behaviour was normal, as was observed at the beginning and as I have tried to confirm in radiographs. Had it not been normal the lower incisors would not have been proclined, and it

would have been inviting relapse to have proclined them to this extent. I have no doubt that some slight degree of forward tilting is permissible in many cases where the upper incisors can be brought back within the influence of the lower lip.

It may be questioned whether this result will maintain its stability in relationship and in alinement. On the former it would be interesting to know what other type of simple treatment might have given a better chance of success. On the latter point I feel that it may be that in the later 'teens, even if the relationship is maintained, there may be a loss of upper incisor alinemcnt during the "uprighting of the incisor teeth" as described by Björk, and it may be that this could be minimized by recourse to extractions even at this stage.

Acknowledgements.—I would like to thank Mr. R. E. Rix and Mr. K. E. Pringle for permission to make use of material and cases under their care at Guy's Hospital, also Mrs. Rawlins for making the tracings, and Miss Whiteley of the Dental Photographic Department for the slides and photographs.

(*J. S. Rose*)

Case 1.—In January, 1953, the patient presented, aged 13 years 8 months. She was of skeletal II clinical appearance, with incompetent lip-seal. Her general posture was very good. The patient sucked her thumb until 10 years old. Her mother had a similar appearance. On examination, she was a very marked Angle II division 1, and skeletal II.

Muscular Pattern.—She swallowed with her cheek teeth together, and had an anterior tongue thrust. During this action the lower lip made a seal against the tongue and $\overline{21|12}$, and contracted behind $\underline{21|12}$.

Arches.—The lower arch was flattened anteriorly. $\overline{|6}$ was missing (extracted about 1 year previously). $\overline{5|}$ was not seen clinically, but was present on X-ray examination. Its space had been lost. The upper arch was high-vaulted, narrow, and relatively long.

The teeth in occlusion showed post-normal relationship with marked overjet and anterior open bite (*Fig.* 1).

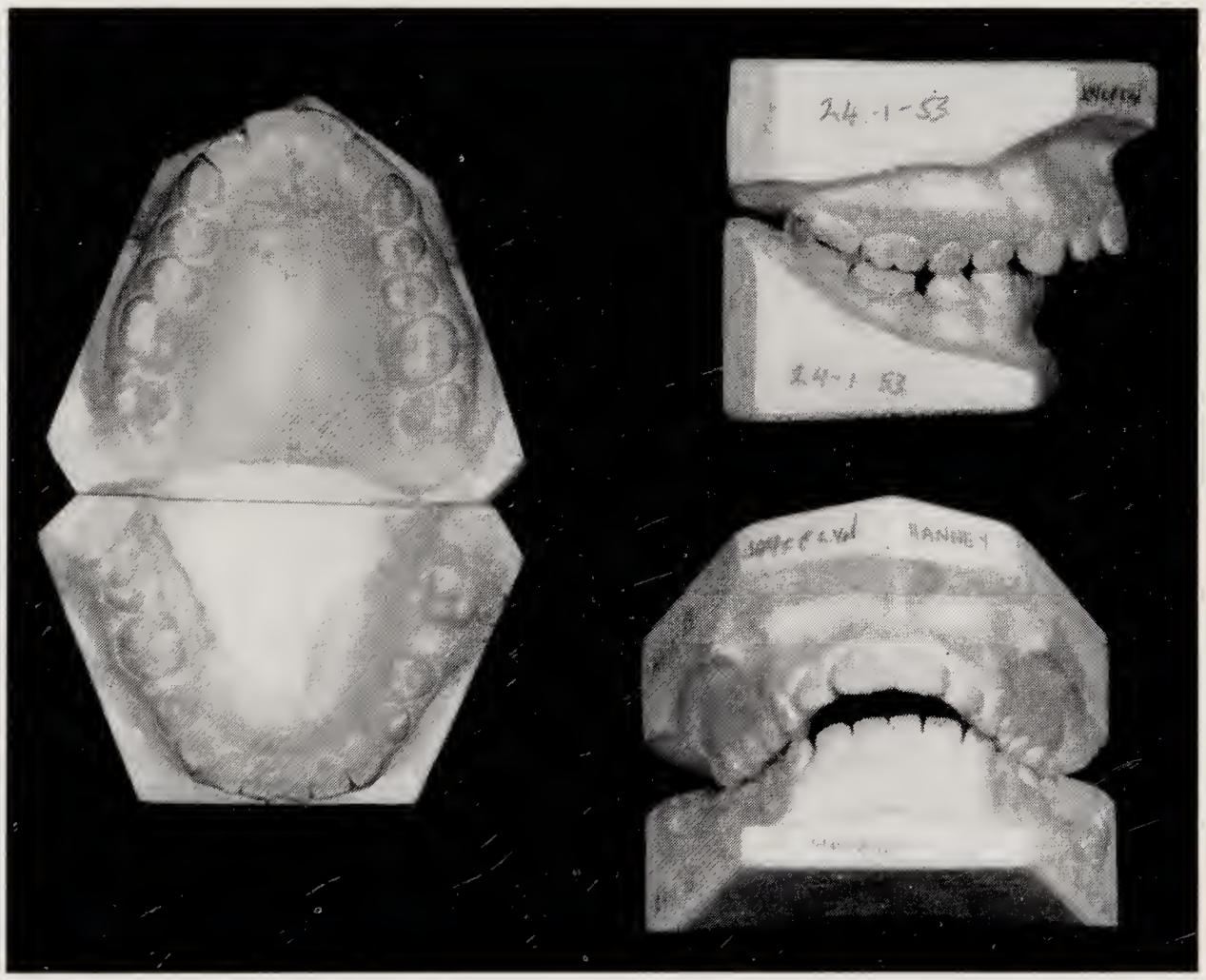


Fig. 1.—*Case* 1. Before treatment.

In view of the age of the patient, and the already collapsed lower arch, together with the adverse muscular pattern, it was decided to treat this case in the following way :—

1. Extract $\underline{4|4}$, and then retract $\underline{321|123}$.
2. Recreate $\overline{5|}$ space.
3. Finish on a monobloc, to exert some Class II traction, and attempt to re-educate the muscle pattern.

its pressure is counter-acted by the position of the lower lip.

Case 2.—This girl presented in November, 1953, aged 3 years 9 months. Her parents are Polish, but she was born in England. Her clinical appearance suggested that the mandible was lagging behind the maxilla. She had sucked her thumb until 2 years old,

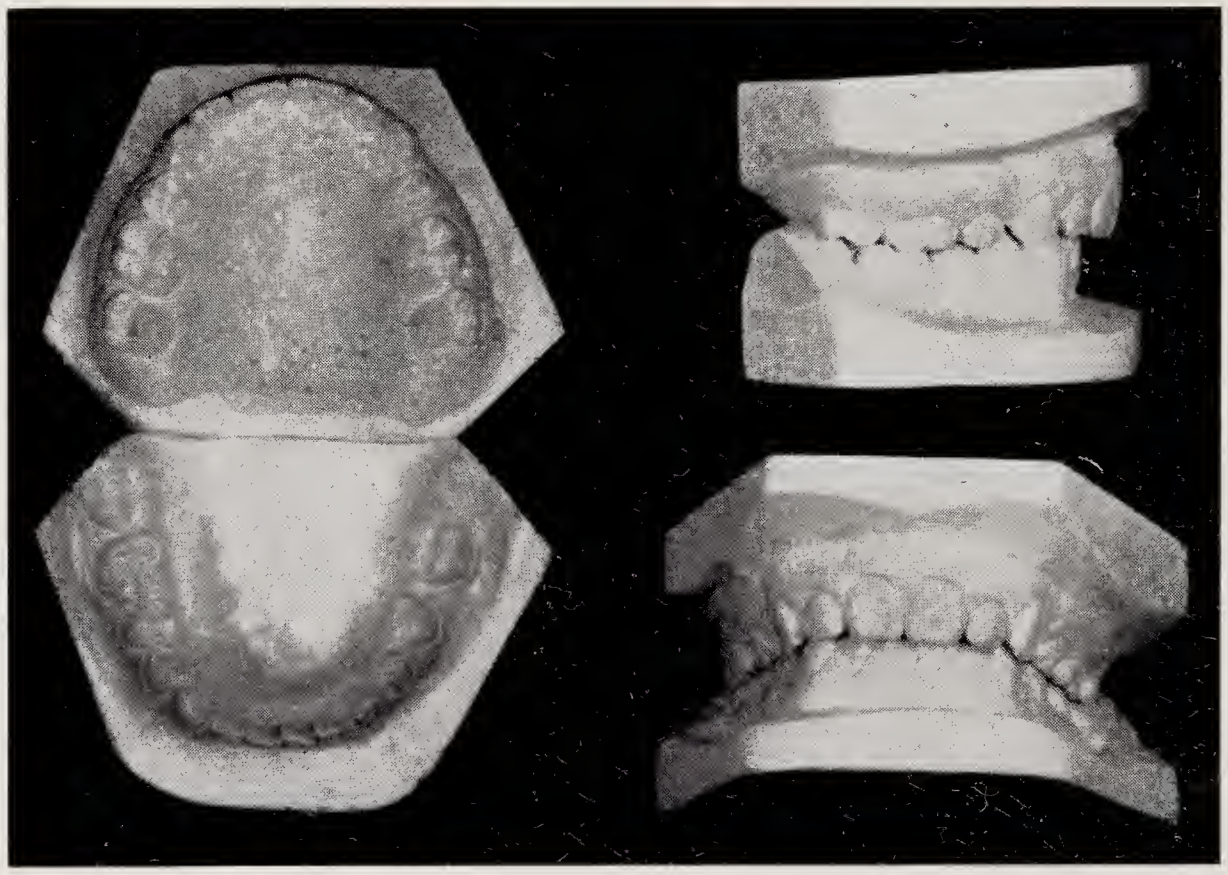


Fig. 2.—*Case* 1. Six months after the appliance was left out.

The object was to recreate the lower arch as far as possible, and bring the upper incisors under control of the lower lip. Treatment was started in April, 1953, and at the end of the second year the case was completed except for retention. *Fig.* 2 shows the models six months after the monobloc had been left out. The condition appears to be stable.

Appliances.—Treatment was done with removable appliances. In the upper a plate with a labial arch and retraction springs to $\underline{3|3}$ was used. Self-straightening wires were used to retract $\underline{21|12}$. To regain $\overline{5|}$ space, Schwarz plates were used. Finally a monobloc was inserted to finish off the case, including adding gutta-percha to push $\overline{5|}$ buccally.

The occlusion is now reasonable and appearance is much improved. During swallowing the lower lip is now in front of $\underline{21|12}$ and the lips are competent. There is still a mild anterior tongue-thrust, but it would seem that

and then stopped of her own accord. Her mother thought the teeth came through with the lowers well behind the uppers. At 1 year old she was very ill. (No history is available.)

Examination showed her to be Angle II division 1, and skeletal II with a cross-bite. There was a deviation of the mandible on closing, sometimes to the left and sometimes to the right, due to the upper being a little too narrow for the lower. The teeth were in good condition.

Muscular Pattern.—This showed an open-mouth swallow with an anterior tongue thrust. There was no lip-seal—the lower lip contracted against $\overline{BA|AB}$ during swallowing.

In spite of her relatively young age, it was decided to start treatment. In February, 1954 (aged 4 years), a removable expansion plate was inserted to achieve normal lateral relationship of upper and lower arches. She was transferred to a monobloc in August, 1954.

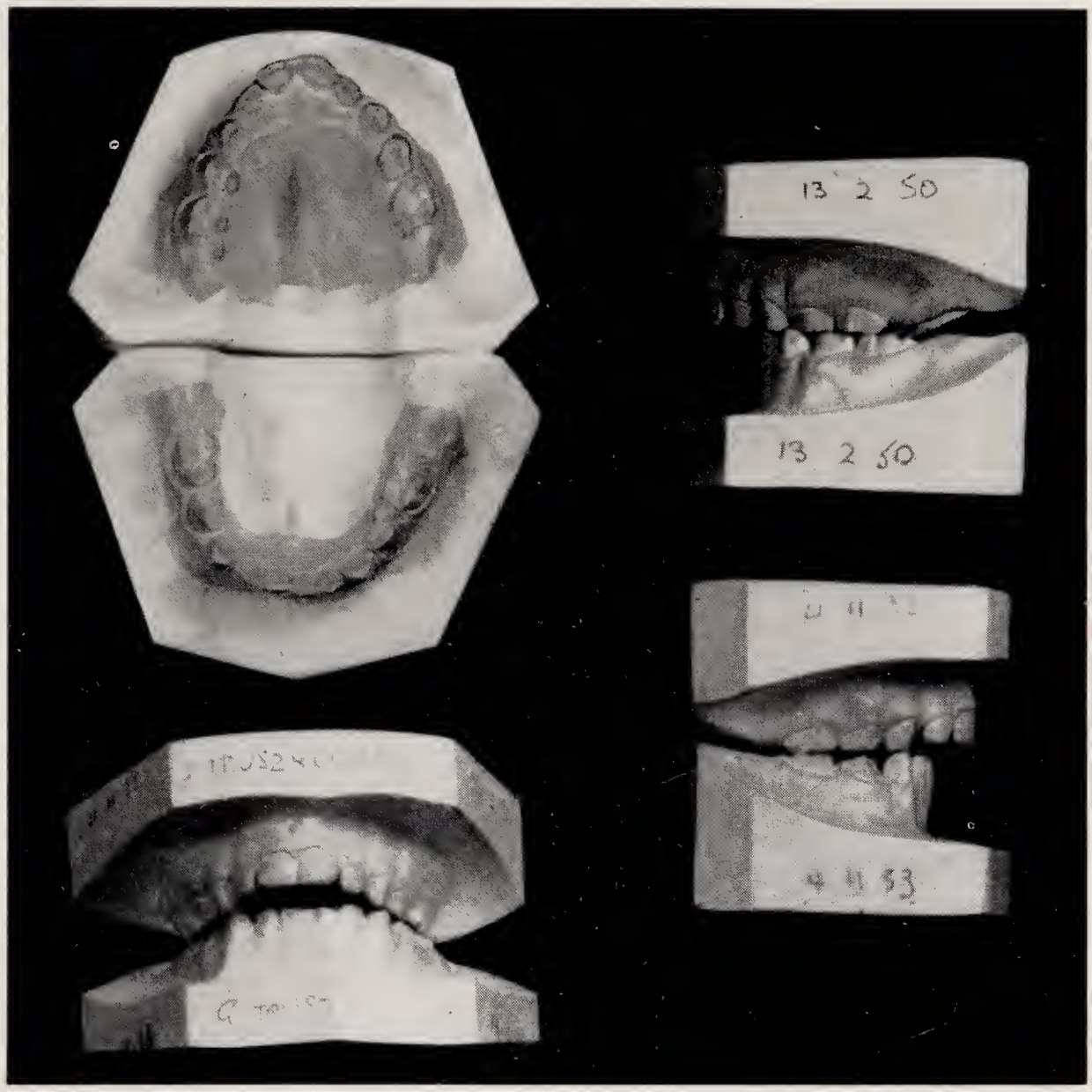


Fig. 3.—*Case* 2. Before treatment.

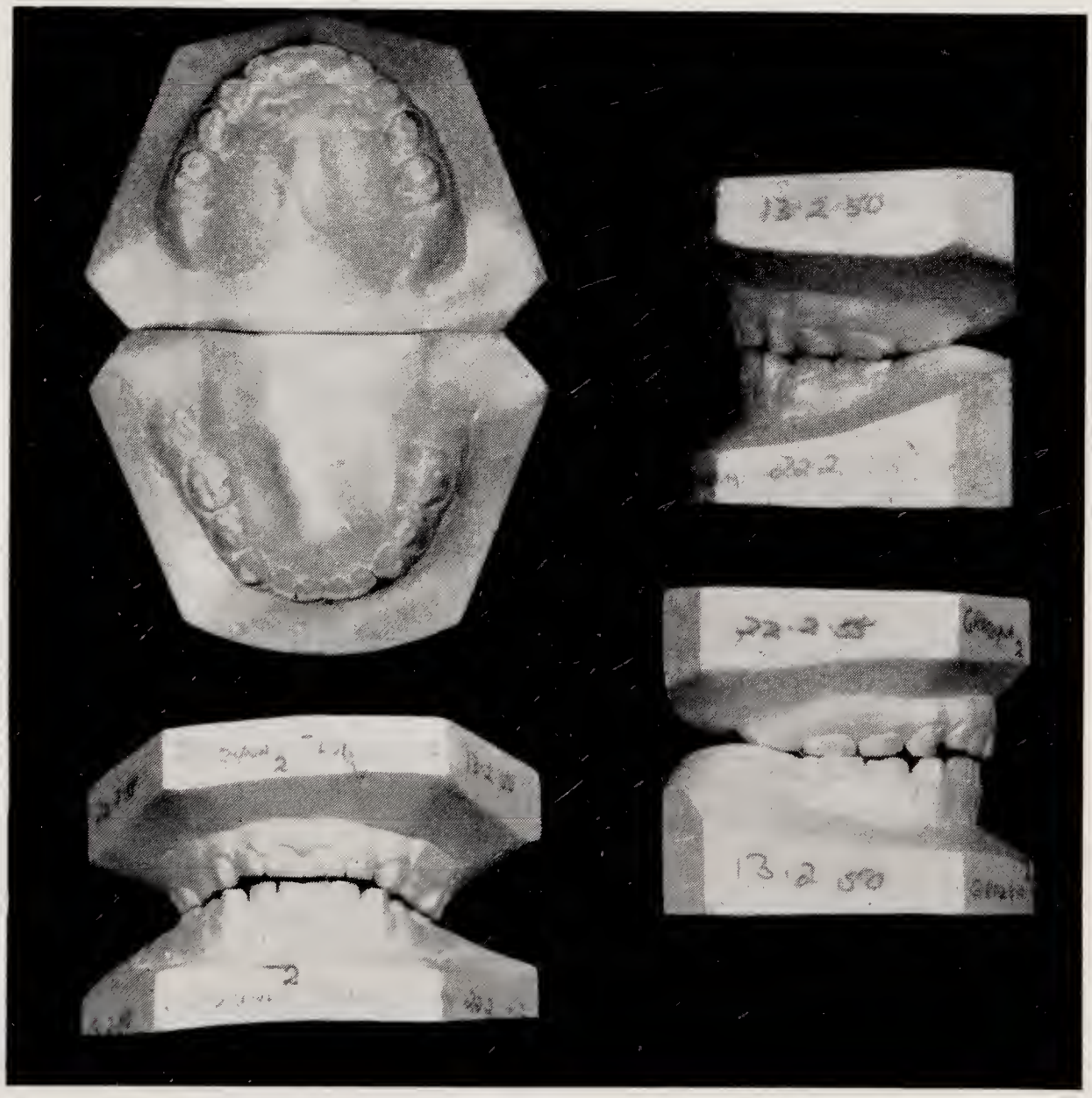


Fig. 4.—*Case* 2. After one year's treatment.

Fig. 3 shows the position at the start and *Fig.* 4 after the end of one year's treatment. During this time $\frac{EC|C}{EC|C}$ had been stoned to allow free lateral movement of the mandible.

Fig. 5 shows the position at the end of a further year. There is now a Class I relationship of the cheek teeth, and the open-bite has been markedly improved. $\underline{21|1}$ are erupting, and $\overline{|B}$ is being shed. The new teeth are relatively large and show hypoplasia which corresponds with the illness at one year of age.

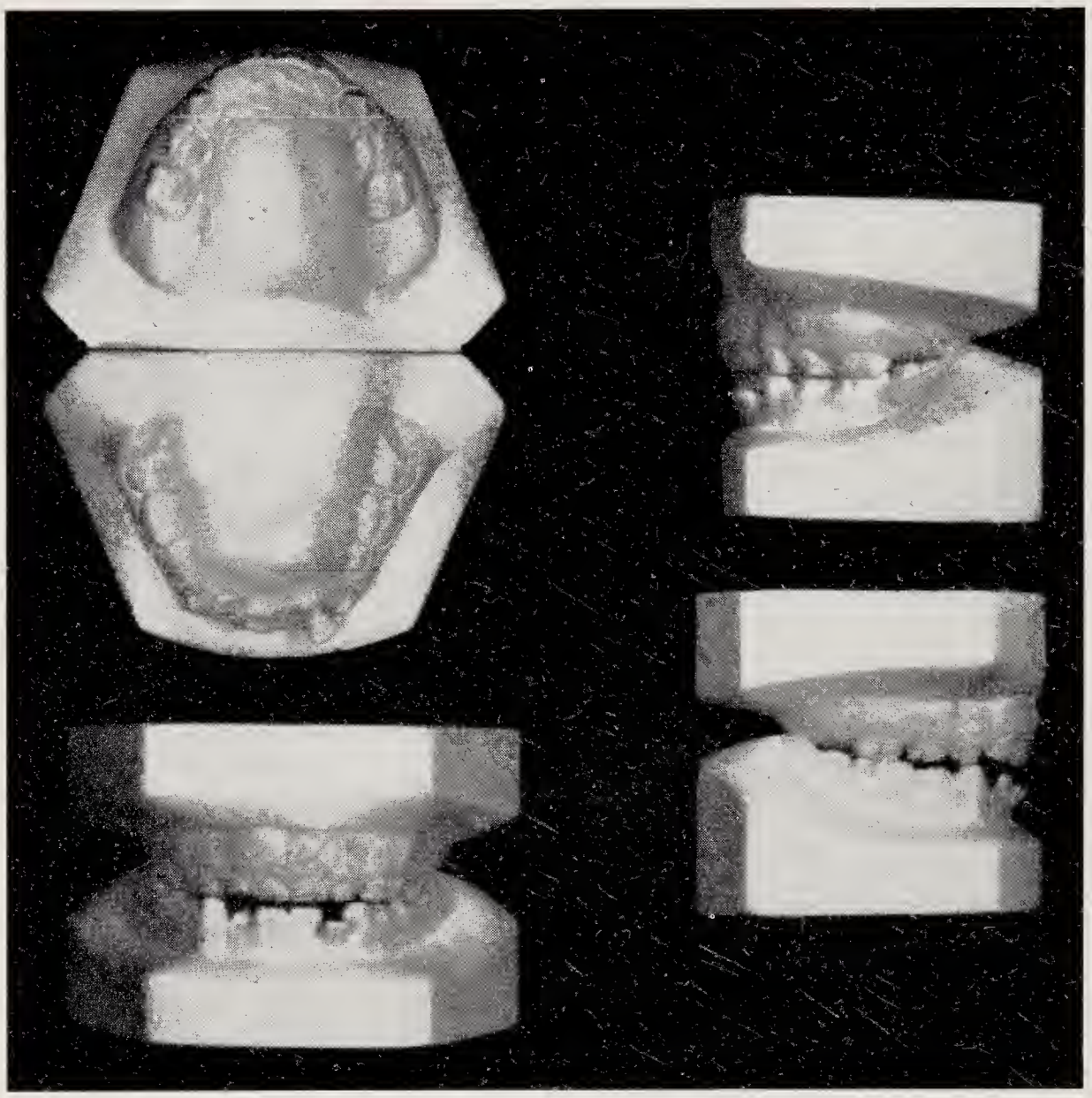


Fig. 5.—*Case* 2. After two years' treatment.

The girl now has a teeth-together swallow, and a slight tongue-thrust with competent lips. I am beginning to leave out the plate, and the case will be watched over the developing years.

The justification of treating such a case so early is very briefly this: any factor that interferes with the normal muscular and skeletal development should be treated as early as possible.

I think it is difficult to say whether the adverse muscular pattern here is present because of the position of the teeth, or whether the position of the teeth has been caused by the muscular pattern. Whichever way it is, I feel that at such a young age one is justified in putting the teeth and dental arches in the optimum position for the muscles to function normally. At the worst the patient has sucked a monobloc for a couple of years; at the best the muscular pattern has been re-established before becoming what may be an untreatable reflex habit.

Both these cases showed similar skeletal, dental, and muscular patterns, but there was ten years difference in their ages at the commencement of treatment. The elder girl also had a collapsed lower arch accentuating the condition. Thus the different treatment plans for relatively similar conditions have been based upon age and the condition of the lower arch. The prognosis for treatment without extraction is much greater in the younger age group—and this also applies to the possibility of altering the oro-facial muscle patterns.

THE APPLICATION OF 8-MM. CINÉPHOTOGRAPHY TO ORTHODONTICS

By **B. C. LEIGHTON,** H.D.D. (Glas.), D.D.O., D.Orth. R.C.S., L.D.S. R.C.S.,
and **D. E. M. WARNER,** D.D.O. (Glas.), L.D.S. R.C.S.
King's College Hospital Dental School

FEW will dispute the advantages of having cinéphotography available in a teaching department, particularly as an aid to instruction in practical technique. There is, however, a special interest in this type of record to the orthodontist, whose attention is being focused more and more upon behaviour and movement during function. In order to apply this medium for recording purposes it is necessary that it should be freely available within the department. It must, therefore, be simple to use and sufficiently inexpensive to allow for a certain amount of wastage; 8-mm. cinéphotography has both of these qualities. Its great depth of focus renders it relatively simple to use in the surgery. It is possible, with the aid of a moviola, to analyse the movements recorded on the film. It may, therefore, be used also as an instrument of research. When projected, the image can be enlarged to a width of 6 ft. The small frame size has, however, one disadvantage: separate frames are not satisfactory for reproduction without retouching.

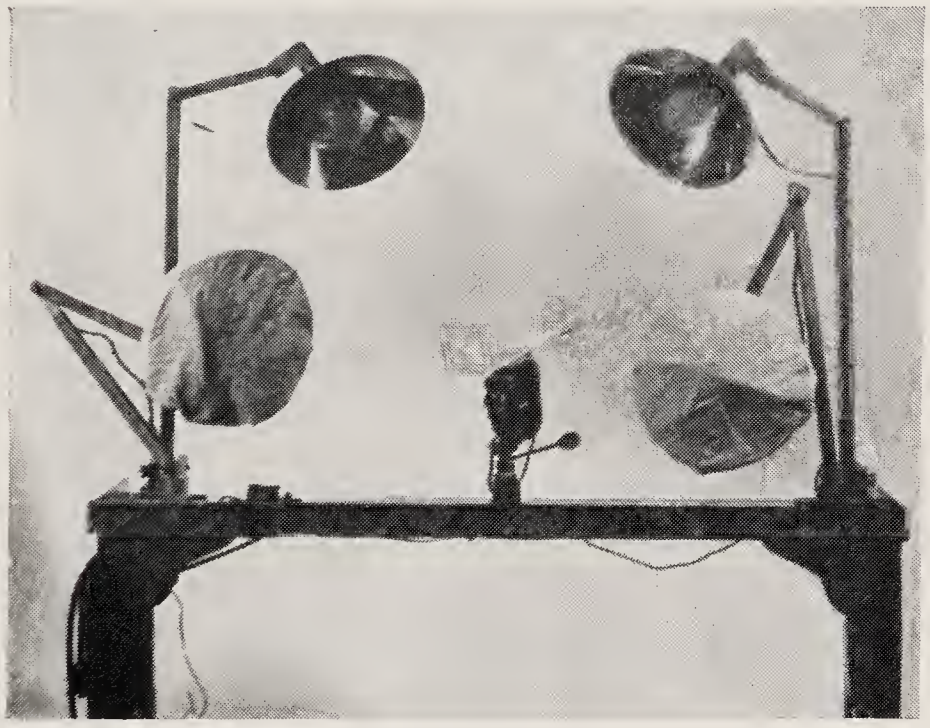


Fig. 1.—Camera and lighting mounted on table.

For clinical use the camera may be mounted on a movable table which can be set astride the chair (*Fig.* 1). Also mounted on the table are four adjustable lamp holders, with reflectors.

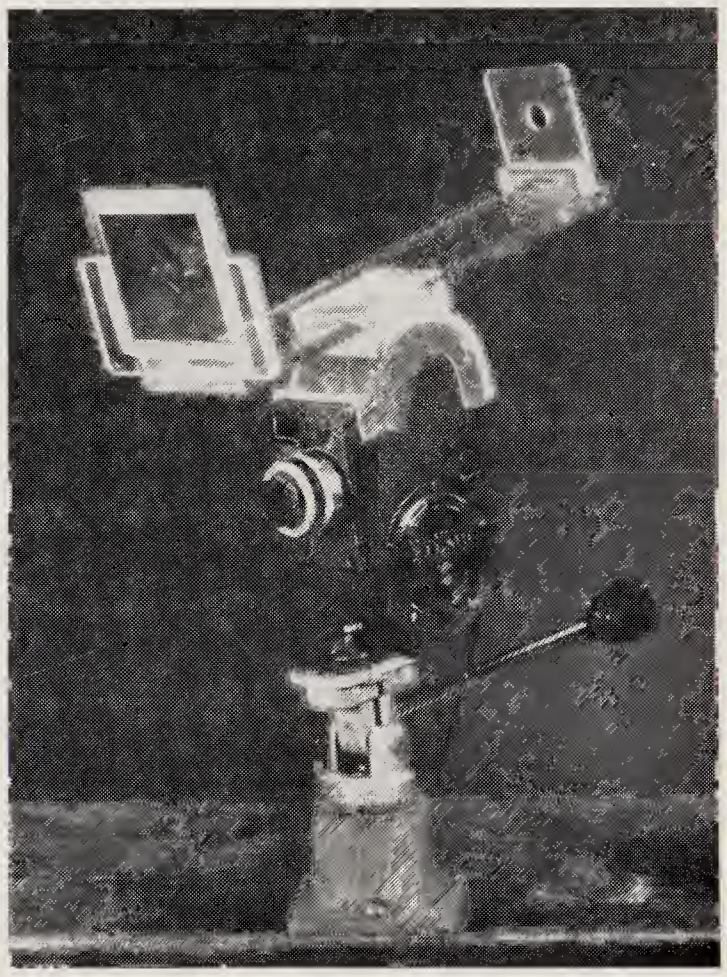


Fig. 2.—Perspex viewfinder with interchangeable frames for various distances, mounted on the camera.

In order not to subject the patient to prolonged incubation the lights may be dimmed while arranging the subject, by switching the lights over to a circuit in series. Because the distance of filming is small, a removable viewfinder has been fitted to the camera, for working at 1, 2, and 3 ft. (*Fig.* 2). When filming in black and white, four standard 100-watt bulbs are used, whereas for colour film two 275-watt photoflood bulbs are used.

A demonstration at the Newcastle upon Tyne meeting held on May 12, 1956.

The authors are greatly indebted to Mr. K. P. Liddelow, Reader in Prosthetics at King's College Hospital, for bringing the possibilities of this medium to their attention in the first place, and for continual help and advice subsequently; and to Dr. R. Cocker, Director of the Dental Department, for much encouragement.

MODIFICATIONS OF STANDARD ORTHODONTIC APPLIANCES

By **J. R. E. MILLS**, M.Sc., F.D.S., D.Orth.

1. AN ATTACHMENT FOR EXTRA-ORAL ANCHORAGE

This attachment is in two parts; a hook on the fixed arch wire and a removable arm which passes round the angle of the mouth and which is attached by an elastic band to the head-cap or cervical anchorage.

Fig. 1.

The hook is shown in *Fig.* 1. It is made of 0·7-mm. hard stainless-steel wire, and is soldered or welded to the arch wire, which may be round, twin-wire, or edgewise. Care is necessary in attaching this hook to prevent softening of the wire by heat; it is important that the wire should remain rigid. It is in the shape of a letter L, with the vertical part about 2 mm. and the horizontal part 4 mm. long.

The arm is formed by soldering a piece of tubing, of internal diameter 0·8 mm., parallel to a piece of 1-mm. stainless-steel wire, at its end. The tubing is then cut off, so that a piece about 5 mm. long is left attached to the end of the wire and parallel to it; at this stage it looks rather like a child's sky-rocket. The wire is bent gently back on itself, so as to pass around the angle of the mouth. A second band is made, at right angles to the first, to form a hook to take one end of the elastic band. This hook thus lies flat against the cheek. The finished attachment is shown in *Fig.* 2. The head-cap is worn nocturnally, and the arm attached to the arch-wire by sliding the tubing over the horizontal part of the hook. This can be seen in *Fig.* 2, where the arm is on the hook but not quite "home". The attachment thus formed is rigid and transmits the pull of the elastic directly along the arch. At the same time the tubing can rotate about the hook, and this allows the arm to settle into the most comfortable position.

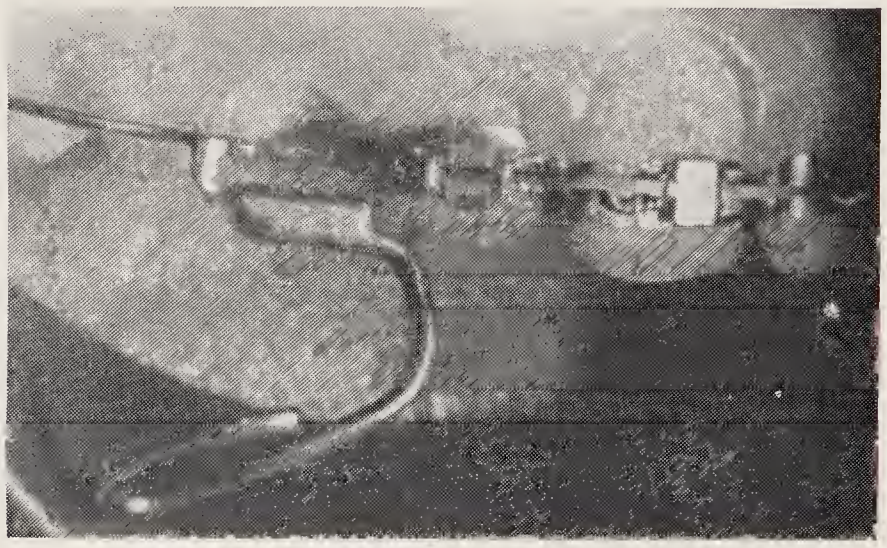


Fig. 2.

2. A MODIFIED LABIAL ARCH WIRE

The arch wire is a modification of the labial wire fitted on the well-known Hawley retainer, and shown diagrammatically in *Fig.* 3. This latter consists of a rigid wire fitting closely around the incisor teeth, with a loop at each end for adjustment purposes. Its rigidity makes it an excellent retention appliance, but the lack of resilience makes it unsuitable for active tooth movement.

The resilience of the wire could be improved by increasing its length. This could only be achieved by making the "take-up" loops longer. If we extend them vertically we change the reflection of the mucosa, so we can only extend them mesially, as shown in *Fig.* 4. Unfortunately the wire then loses control of the canine and even, possibly, the lateral incisor.

A demonstration at the Newcastle upon Tyne meeting held on May 12, 1956.

The solution to this problem is seen in *Fig.* 5. The labial wire is taken to the distal margin of the canine, and then bent back upon itself for a distance, before being bent at right angles, to form the usual adjustment loop. With this arrangement the canine is firmly controlled,

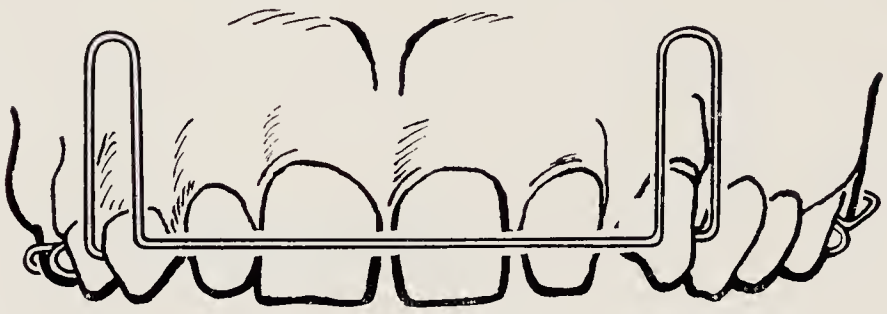


Fig. 3.

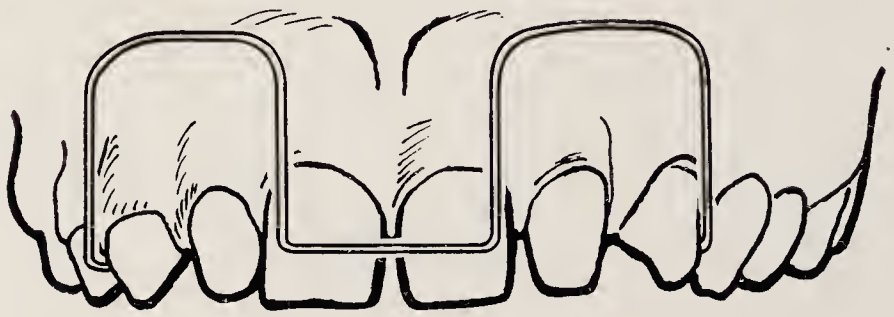


Fig. 4.

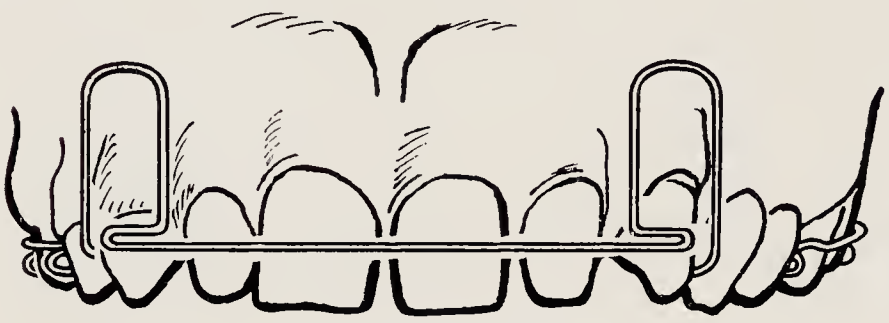


Fig. 5.

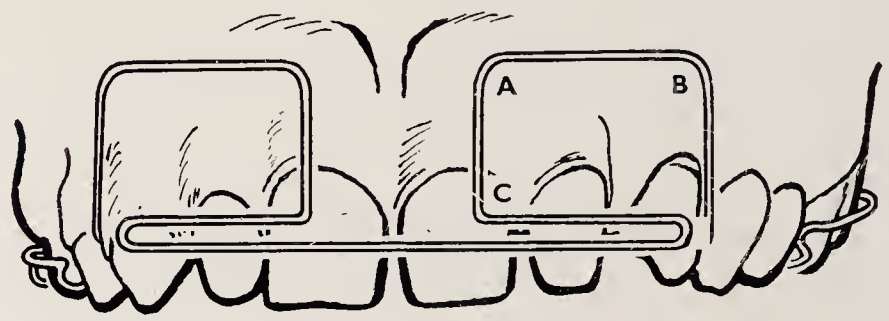


Fig. 6.

and the size of the loops can be extended mesially until they almost meet in the middle, as shown in *Fig.* 6.

If constructed in 0·7-mm. stainless-steel wire, this produces a labial arch wire of adequate resilience, which may be used for lingual movement of the upper incisor teeth or for alinement and rotation of teeth by "squeezing" the teeth against the acrylic on their lingual side. For either of these purposes the lingual acrylic must be trimmed away suitably.

Adjustment is effected by decreasing the radius of the curves A and B, thus closing the adjustment loops. This causes the distal ends of the wires to bend gingivally, which effect may be counteracted by opening the corner C.

The appliance, which in my hands is simpler both to make and to use, forms an alternative to the "apron spring".

I wish to express my thanks to the Department of Medical Illustration, United Manchester Hospitals, for the illustrations.

AN INTERESTING CASE OF DEVELOPMENT

GROWTH IN WIDTH OF THE MAXILLARY ARCH BETWEEN 8–11.9 YEARS

By **JOAN WEYMAN**, B.D.S., F.D.S., D.Orth. R.C.S.

THE patient was aged 8 years when first seen in January, 1951. Her occlusion was Angle's Class I with some tendency to Class III. There was a cross-bite of all the left cheek teeth,

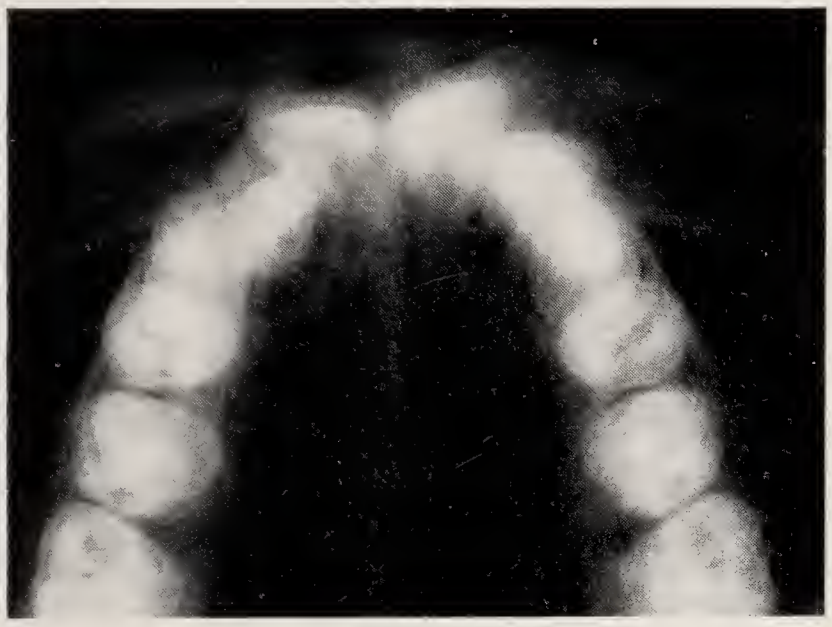


Fig. 1.—On January 19, 1951, aged 8 years.

Fig. 2.—On October 28, 1954, aged 11 years 9 months.

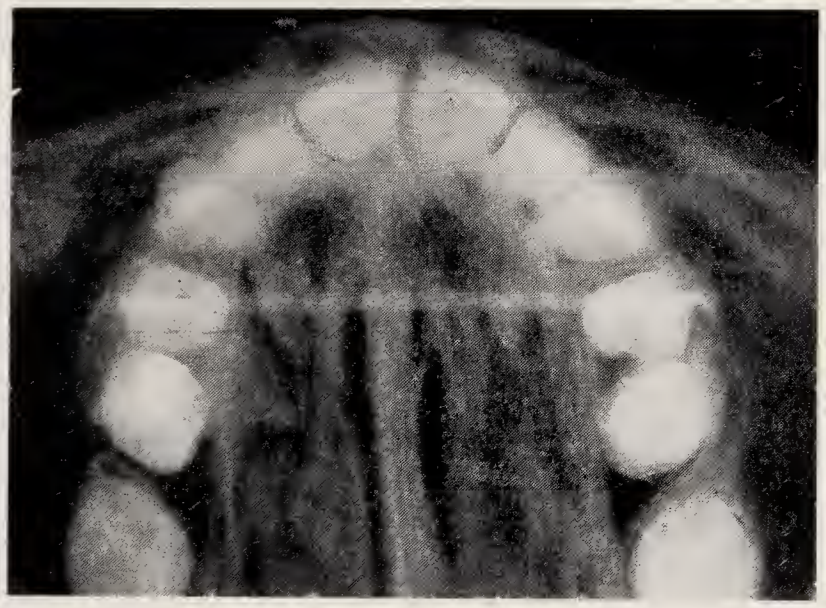


Fig. 3.—Check for accuracy.

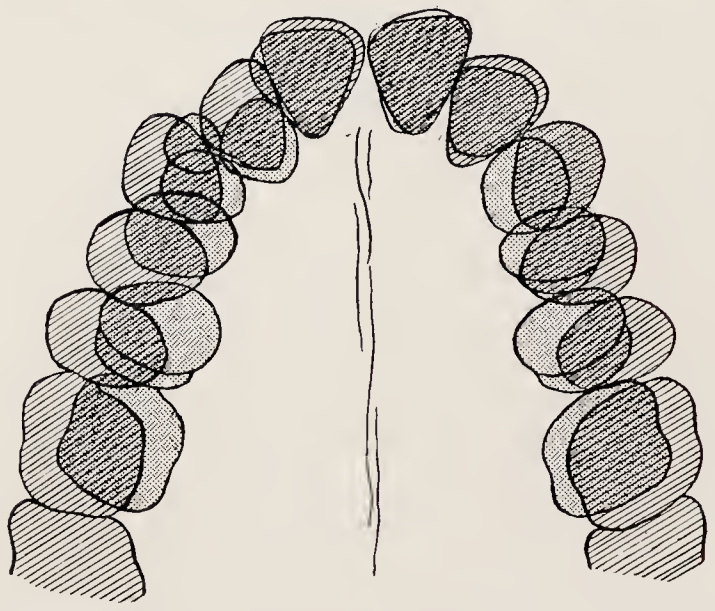


Fig. 4.—Superimposed tracings of enlargements of the occlusal radiographs.

$\underline{|2}$ was blocked out in lingual occlusion, and there was also some irregularity of the other maxillary incisors (*Fig.* 1). Radiographs were taken at the time but no models, and she was then put on the orthodontic waiting list.

She was not recalled for treatment until October, 1954, and she assured us that she had had no orthodontic treatment meanwhile. It was found that a great change had taken place (*Fig.* 2). There was no longer a cross-bite present, nor was $\underline{|2}$ in lingual occlusion. A considerable increase in width of the arches had occurred, more so in the maxilla than in the mandible. The incisors were so much improved that it was felt that no treatment of the malocclusion was necessary. The occlusal radiographs were repeated and it was found that the increase in width, measuring the external $\underline{6|6}$ distance on the two radiographs, was 6 mm.

It was of importance to know that the radiographs accurately portrayed the width of the arch, both because the measurements were compared and as they were to be used

A demonstration at the Newcastle upon Tyne meeting held on May 12, 1956.

for superimposed tracings. To check this, another patient was radiographed using slightly different angulations, but as far as possible duplicating the views taken of the original patient. These films had fastened to each of them in the transverse direction (i.e., across the arch) a strip of metal of exactly the same length, and the resulting radiographs were compared for the length of this metal strip (*Fig.* 3). As they were of identical length it was assumed that in these views there was no distortion of the arch width.

The enlargements which were to be traced were made on glass negatives and traced directly off these, as it was found that there was considerable distortion in making positive prints on paper. The tracings were superimposed over the mid-point between the two central incisors and oriented on the medium septum as far as possible (*Fig.* 4).

The first radiograph of the mandibular arch of this patient was not found suitable for tracing or measuring, so it was not possible to show the change in this arch.

I should like to thank the Radiographic and Photographic Departments of the Newcastle upon Tyne Dental Hospital for the trouble they took with this case.

SPEECH AND THE ORTHODONTIST

By **G. B. HOPKIN**, H.D.D., D.D.O., L.D.S.

The Orthodontic Department, University of Edinburgh Dental School

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Department of Orthodontics and Children's Dentistry, University of St. Andrews, Dental School, Dundee: Formerly at the Orthodontic Department, University of Edinburgh Dental School

McKeag (1956) suggests the recording of the life histories of individual dentitions "together with information on masticatory and speech habits". If the orthodontist is to study speech habits he must have some knowledge of the anatomy and physiology of speech, and especially must he understand the parts played by the teeth, lips, and tongue in speech production. In the past this subject has been neglected in dental education, but to-day there is a growing co-operation between Speech Therapists and Orthodontists.

This paper is divided into two main parts: the first part discusses some aspects of the anatomy and physiology of speech; the second deals mainly with our clinical observations. The authors have made some examination of those parts of the organs of speech of interest both to speech therapists and orthodontists, and the relationship of the jaws to each other and the actions of the tongue, lips, and related parts of the facial musculature.

The authors are only too aware of their deficiencies for such a task and hope to stimulate someone more competent to work in this field.

The part played by jaw relationships is considered later in the presentation of the clinical material and it is proposed now to consider briefly some aspects of the evolution of both the genioglossus muscle, and its relation to the chin and the lips.

In the latter half of the nineteenth century a theory gained hold that the development of the chin was due to the development of speech, and in particular to the change in the origin of the genioglossus muscle, which arises from a pit in anthropoids and from a tubercle in man.

Increased functioning of genioglossus was held to cause the development of the chin.

Robinson (1914) considers not so much the development of the chin as the development of the genioglossus muscle. The genioglossus shows a marked development in man as compared with other mammals. In the pig and dog it is a mere slip; in the apes it is a single muscle or closely united group acting *en bloc*; in man it has become a series of independent strips which Robinson regarded as to all intents separate muscles, each with a separate nerve-supply.

He considers the genioglossus to be the only structure capable of exercising the quick and exact control of the tongue necessary for making the movements in the anterior part of the mouth, where 80 per cent of consonantal sounds are made, and he further stresses the fact that the majority of speech movements take place in the midline.

Correlating the genial tubercle with speech, Robinson says that most anthropoids are silent, but chimpanzees and gibbons come nearest to articulate speech.

His conclusion is that the genial tubercles, whilst not strictly necessary for speech, greatly facilitate its production.

Thompson (1916), after an extensive examination of a large number of skulls, concluded that the assumption that the occurrence of genial tubercles in man is necessarily associated with articulate speech is not justified by the facts—namely, that in many human mandibles they are absent and in numerous cases they are replaced by isolated pits or depressions. In rarer cases isolated pits coalesce to form a fossa, and in these cases there is no evidence to suggest that the individuals concerned were less capable of speech than their fellows.

Du Brul and Sicher (1954) consider that the origin of the chin is due to the buttressing

Given at the meeting held on October 8, 1956.

required in the region to withstand the altered muscular forces acting on the lower jaw as a result of the assumption by man of an erect posture.

Thompson accounted for the mental process by the need for greater strength in the basal part of the jaw due to the lessened alveolar portion owing to the smaller teeth of man compared with anthropoids. He did not find that the so-called trajectories of bone running from the genial tubercle to the mental process were due to speech as they were absent in some cases. He concluded that they were determined by the general architecture of the bone and the grouping and modelling of its parts. Duckworth (1947) discusses the organs of speech; of the tongue he remarks on the lack of information regarding the tongue in anthropological literature, most racial comparisons having been on the distribution of sensory papillæ, and he stresses the need for information as to the muscular structure of the tongue both as regards its intrinsic and extrinsic musculature. In view of the racial differences in lip structure which are referred to later, he asks whether similar differences can be found in the tongue.

Evidence of a difference in functional ability possibly based on an anatomical difference is provided by Sturtevant (1940), who found in 280 individuals two fairly distinct groups with respect to the ability to turn up the lateral edges of the tongue. In a typical positive case the edges can be rolled together. In the negative cases there is no turning up of the edges. A few intermediate cases were encountered, and in quite a number of cases the ability at first absent was acquired with practice. These latter were all children except for one adult.

As to the mechanism by which these differences appear, speaking very generally, one assumes they are due to mutations and their perpetuation by genetic factors.

Darlington and Mather (1949) wrote: "certain racial family and individual differences in tongue shape and movement are so sharp as to be obviously hereditary". They quote the well-known Biblical example of the division of the Jews into those who could and those who could not pronounce the word Shibboleth (Judges xii. 4–6).

They consider that "the genetic control limits not so much the ability *as the ease* with which the races and individuals are capable of uttering the various sounds within the range of the human voice".

They illustrate the role of genetic factors in language by suggesting a correlation between the distribution of the O blood group in Europe and the use of the Th sound in speech. We should, however, stress that Darlington and Mather's theory, interesting though it is, is not generally accepted by geneticists and phoneticians.

There is therefore need for further research concerning both the anatomy of the tongue and, as we shall stress later, concerning its control by the central nervous system. For the moment we think that both speech therapists and orthodontists would on occasion agree with the apostle James when he said in another context "the tongue can no man tame, it is an unruly evil" (James iii. 8).

To turn now to the facial musculature, the following observations are derived chiefly from the extensive writings on the subject by Huber (1930), Lightoller (1926), and Burkitt and Lightoller (1927 a, b).

Huber traces the evolution of the facial musculature from the lower vertebrates to mammals, but we, however, are only concerned with the primates. In general, whilst that of anthropoids resembles that of man, the facial musculature in man far exceeds that of anthropoids in structural differentiation and functional perfection. Among the various races of man there are also differences in the degree of structural differentiation. Huber, Burkitt, and Lightoller comment on racial differences in the facial musculature which, whilst of interest in so far as they help to explain differences in facial form, contour, and expression, are not of such immediate interest as the muscle orbicularis oris. This muscle has been minutely studied by Lightoller. He does not agree with the description current in most text-books of anatomy in which it is described as being derived from the various muscles running into

it, principally the buccinator, the fibres of which are said to decussate at the angle of the mouth before running into the upper and lower lips.

Briefly Lightoller's conception is as follows:

The orbicularis oris is a separate muscle which can be divided into a main body or

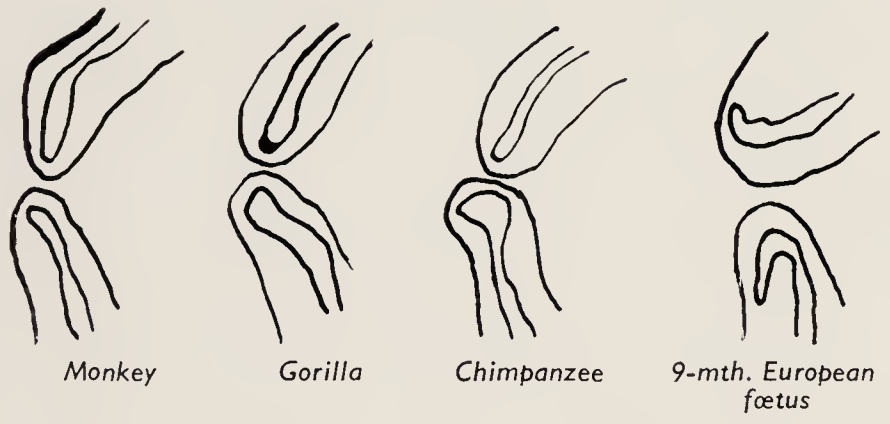

Fig. 1.—Diagrammatic representation of sections of lips of primates. (*After Duckworth.*)

corpus, the pars peripheralis, and a smaller part, the pars marginalis. Whilst other authorities are not agreed upon the separate entities of the pars peripheralis and pars marginalis, Lightoller is convinced from his dissections that they exist and are important.

The fibres from right and left sides meet in the midline; laterally the fibres run into the "modiolus", the term used by Lightoller to describe the muscular mass formed lateral to the angle of the mouth by the meeting of muscles surrounding or running towards the rima oris.

The muscles entering the modiolus are inextricably intertwined so that the "core" or "knot" can be moved in all directions and fixed in any position by one group of muscles, so that it can serve as the origin for other muscles. Lightoller regards it as an area of the greatest importance both anatomically and physiologically. Its strength and position enable the movements of the lips to be made with the precision and accuracy necessary for all forms of speech.

The pars peripheralis or corpus of the orbicularis oris forms the main bulk of the muscle, thickest at the rima oris and extending as far as the septum nasi above and the sulcus mentolabialis below. In section the

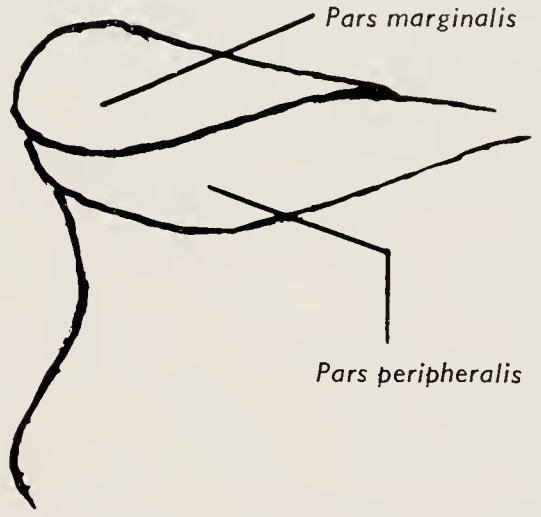

Fig. 2.—Diagrammatic representation of marginal and peripheral portions of M. orbicularis oris. (*After Lightoller.*)

orbicularis oris does not lie all in the same plane but is curved at its rimal end, making the section sickle-shaped, the tip being formed by the pars marginalis (*Fig.* 1). The pars marginalis consists of the marginal fibres; they lie in a plane anterior to the pars peripheralis in the form of a crescent forming the tip of the hook already referred to. This hook formation as viewed in section is more marked in the lower lip.

The pars marginalis takes origin in the deepest portion of the modiolus, just adjacent to the mucous membrane and deep to the pars peripheralis; it curls around the whole thickness of the pars peripheralis and eventually lies wholly anterior to it, where it forms the red margin of the lips, the amount of which therefore depends on its point of crossing over the pars peripheralis (*Fig.* 2).

Lightoller suggests that with the separation of pars marginalis from the corpus of the muscle it has developed independently. He found in the chimpanzee a stage in the transition from a fully formed orbicularis oris consisting of a pars marginalis and pars peripheralis to the more primitive type consisting of a pars peripheralis only.

Duckworth (1910), in his observations on the shape of the orbicularis oris in man and

many animals, agrees in general with Lightoller. He found no trace of hook-like formation in the gorilla, monkey, and lower forms of animal life, but found it in a modified form in the chimpanzee, more marked in the lower lip and well marked in human material, but he does not describe the pars marginalis and peripheralis of Lightoller (*Fig.* 1).

What is the significance of this difference in lip structure? According to Lightoller it is the difference between speechlessness and speech. He considers the pars marginalis to be an anatomical modification adapted for speech and that the separate functioning of the pars marginalis enables the lips to function as labial cords in speech production.

How has this come about? Lightoller suggests that as long as the orbicularis oris was used as a prehensile organ and was extremely powerful at its margin as well as in its corpus, the pull of its powerful antimeric labial tractors would have but little effect on its form, but when the lips ceased to be prehensile organs and were being used in a modified way for speech, then the marginal portion would become weaker and be dragged slightly forwards and upwards by the upper labial tractors and forwards and downwards by the lower labial tractors. Originally this would expose some of the mucous membrane of the mouth, but in course of time it would become modified to form the red lip area. Lightoller regards therefore the pars marginalis as a speech modification.

In support of his hypothesis that the pars marginalis is a speech modification Lightoller observed differences in the upper and lower lips of human fœtal and adult specimens similar to those in the upper and lower lips of chimpanzees. He points out that this difference is to be expected as the lower lip is the more important for speech; the place of the upper lip can be taken by the upper incisors for bilabial sounds if necessary.

Lightoller further discusses the balance between the labial tractors and the pars marginalis orbicularis and he writes as follows: "With a powerful (and primitive) pars marginalis orbicularis oris and less or equally powerful labial tractors we would expect little or no red lip showing. This has been shown to be phylogenetically the case and a similar condition may yet be seen in the faces of many men, giving to the face an expression of vigour and sometimes cruelty. With a weak pars marginalis orbicularis oris and equally weak labial tractors a similarly small amount of red lip might be expected. With a weakened pars marginalis orbicularis oris but powerful labial tractors, we might expect the maximum of red lip to be visible. Such conditions are often seen and give to the face a sensual or voluptuous cast."

Here then we may have the anatomical basis for competent and incompetent lips arising from a modification of the lip musculature which has been adapted for the purpose of speech. We would like for a moment to comment on the question of competent and incompetent lips. We are not quite clear where the dividing line between competence and incompetence is drawn. We are not sure whether it is decided by the contact or lack of contact of the upper and lower lips at rest, or by the contact or lack of contact of the lower lip with the upper incisors at rest. If it is decided by the latter we would agree with the definition; if by the former lip-to-lip contact, we would not. In a survey by one of us into the incidence of malocclusion the relation of the lower lip to the upper incisors was noted and it was found in many cases that although the lips were parted at rest the lower lip still contacted the upper incisors. We wondered at the time whether these cases of lips apart at rest were due to a less than usual number of fibres of the buccinator decussating before passing into the orbicularis oris. We could find no references covering this point until reading Lightoller's work, which we think gives the correct answer. It would appear that from an anatomical viewpoint closed or parted lips at rest are both within the range of normal, being part of the infinite variety that characterizes all living things, but, orthodontically, parted lips should in our opinion be regarded as outside the limits of normality, when the lower lip fails to contact the upper incisors.

Huber, in the light of the past evolution of the facial musculature and the present marked racial and individual differences, considers that further evolution towards greater differentiation is taking place, and Huber also says that "there is no doubt that the acquisition and gradual perfection of articulated language has had a further decisive influence on the evolution of the mimetic musculature and facial expression". Fundamentally therefore those aspects of speech dependent on the facial musculature and those malocclusions in the aetiology of which the facial musculature plays a causative role are not related casually but both stem from evolutionary changes, and, this being so, the orthodontist must recognize this fact in his clinical assessment, and must therefore expect to find as much variety in the morphology of the soft tissues as cephalometry has taught him to recognize in bony structure.

THE RELATIONSHIP OF SPEECH TO THE DENTITION AND ASSOCIATED PARTS

Speech is such an accepted part of man's make-up that we seldom pause to consider that it is not an inherited function. The various organs used in the creation of speech are primarily used for other functions; speech is an overlaid function, which depends on the working of the auditory, motor, and cerebral systems. If one considers the complexities of these systems and the defects which may occur, it becomes obvious that the part played by an abnormality of the dentition and associated parts must be a relatively small one.

The sections of our paper dealing with the mechanics of speech and the use of Anthony's palatography machine have been omitted, as the ground covered by these sections has been dealt with in the account of our demonstration of palatography given at the Sheffield Country Meeting in 1955 (Hopkin and McEwen, 1955).

During speech there is of course considerable activity of the tongue, and in uttering the linguo-alveolar consonants it must exert a definite pressure. We had hoped to ascertain these pressures in normal and defective speech sounds, but we have only been able to obtain to date pressures for normal speech and swallowing.

Accounts of apparatus used for recording tongue pressures have been given, such as those by Margolis and Prakash (1954), Alderisio (1953), and Feldstein (1950), but they give no detailed findings of the pressures measured. Neumayer (1937), using a small balloon connected to a manometer, is quoted by Kaier (1942) as recording average tongue pressures of 4·8 kg. in men and 3·9 kg. in women.

Fig. 3.—Experimental plate showing pressure chamber with rubber diaphragm in palate, lead to manometer, and escape tube.

Friel (1924), in his work on oral muscular pressures in children, using specially designed dynomanometers, found tongue pressures varying from 6 oz. to 5 lb. 7 oz. The majority of the tongue pressures recorded lay between $2\frac{1}{2}$ lb. and $3\frac{1}{2}$ lb.

Feldstein found an average pressure by the tongue against the first molars of 3·5 g. during the drinking of 40 c.c. of water.

Description of Apparatus.—The apparatus we used consisted of two parts. The part in the subject's mouth is similar to that used by Stetson (1951). It is a removable acrylic appliance incorporating a chamber in the alveolar region behind the incisors (*Fig.* 3). The chamber is covered with a rubber membrane and is connected to the recording apparatus by a tube which is led out of the mouth distal to the last molar. This is done to prevent interference with the bite. A second tube which is later sealed is used as an escape

when the circuit is filled with fluid. It was found necessary to have a fluid-filled circuit, as when air was used the tongue was able to compress the rubber against the bottom of the chamber, thus creating errors in the recording. The recording apparatus was based on a Wiggers membrane manometer (*Fig.* 4). It

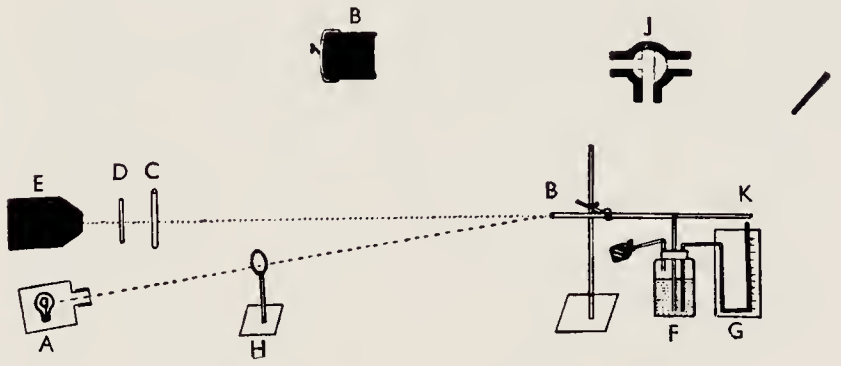

Fig. 4.—Diagram of recording apparatus; for description *see* text.

consisted of a source of light (A) which is focused on a small mirror (B) on the rubber diaphragm closing the other end of the fluid-filled circuit. The reflected light from the mirror is focused on the cylindrical lens (C),

Table I.—Summary of Pressures Recorded during Swallowing and Speech

Action	*Subject: J.D.M.*	*Pressure lb./sq. in.*
Swallow saliva	2·0 2·8 3·0 3·2 3·0 2·6 3·5 1·9	
Swallow water	2·6 2·0 2·6 2·3	
Speech "tip"	1·5 1·1 1·1 3·2 4·3 3·0 2·3	'dip' 2·0
Action	*Subject: G.B.H.*	
Swallow saliva	3·9 4·6 3·4 3·5 4·4 2·0 4·6	
Speech "tip"	0·78 0·51	'dip' 0·91 0·64
Speech "sip"	No measurable record.	

which collects the light on to a ground-glass screen (D). It is then photographed by the motor-driven camera, the recording film moving at a known speed. A reservoir (F) is attached to the fluid circuit by a junction (J), allowing various settings. The reservoir is joined to a mercury manometer (G) and has a hand pump. The two parts of the apparatus are joined at K and the circuit is filled with fluid and sealed.

Method of Use.—The junction is set from mouth to mirror and the experiments carried out with the subject swallowing and pronouncing linguo-alveolar sounds T and D. To allow a scale to be taken, the setting is changed from mouth to mirror, to reservoir and manometer to mirror, and several pressures taken and photographed. *Fig.* 5 shows examples of the records obtained for swallowing and speech.

Experimental Findings.—The pressures obtained during the swallowing of saliva or sips

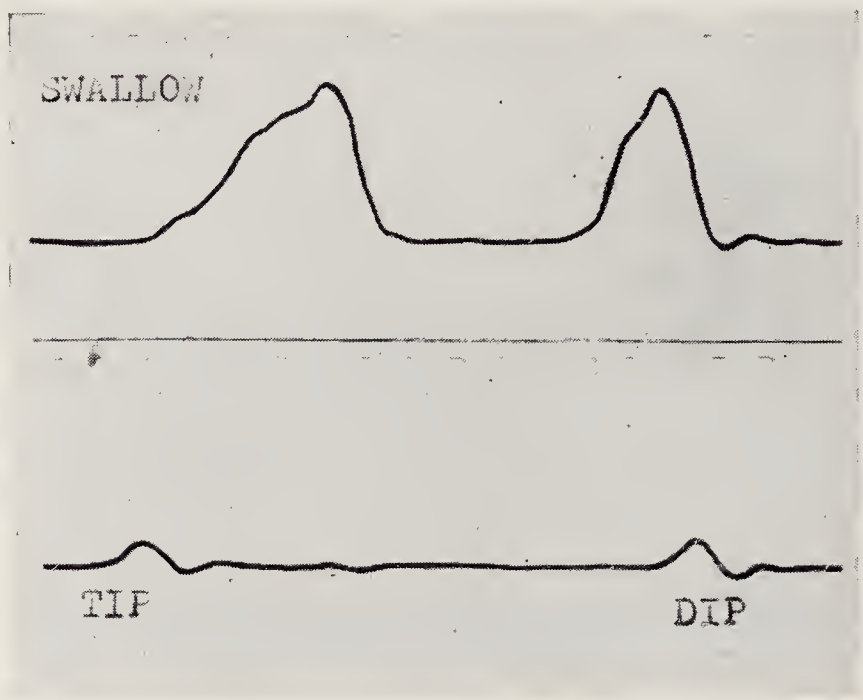

Fig. 5.—Typical pressure wave recordings for swallowing and speech.

of water ranged from 2·0 to 4·6 lb./sq. in. A total of twenty swallows were recorded (JDM 13, GBH 7). Detailed findings are shown in *Table* I.

The speech sounds for which pressures were recorded were T in "tip", and D in "dip". No measurable pressures could be recorded for the S sound in "sip".

The majority of the pressures recorded varied from 0·51 to 2·3 lb./sq. in. There was no significant difference for the two consonants.

In one series of powerful enunciations a pressure of 4·3 lb./sq. in. was recorded. Details of the pressures are shown in *Table* I.

The duration of the pressure used in swallowing from start to finish, including the build up and relaxation, varied from just under 1 sec. to just under 2 sec. Speech sounds averaged about $\frac{1}{2}$ sec.

Discussion.—The findings for tongue pressures agree with the majority of Friel's figures whilst they are lower than those of Neumayer. There are two qualifications, however, to remember: firstly, Friel's subjects were

children and Neumayer's were adults; secondly, in both cases the force was deliberately exerted as a single act and did not comprise part of the functional movement of swallowing. (This is assumed in Neumayer's case.) When allowance is made for these factors it would appear that our findings are in closer agreement than would appear at first sight.

With regard to the pressures exerted during speech, they fall well within the range of force exerted by the tongue in swallowing and they last for an appreciably shorter period.

Preliminary experiments with lip pressures during speech and normal swallowing indicated that they were minimal and did not equal the tongue pressures. Larger pressures were indicated but not recorded from lip activity during an artificial atypical swallow, as was to be expected, and which has been shown electromyographically by Tulley (1953).

During swallowing the forward pressure of the tongue is applied mainly to the incisal area of the palate and only to a small extent on the crowns of the incisors themselves. Therefore in considering the concept of tooth position as a resultant of the intra- and extra-oral muscular forces, consideration must be given to the resistance offered by the alveolar bone, and the question arises as to how much pressure is applied directly to the palatal surface of the incisor crowns and how much is transmitted through the alveolar bone to the palatal surface of the incisor roots during swallowing and speech.*

Clinical Findings.—The following cases were either referred primarily for orthodontic treatment or for an orthodontic opinion in relation to a speech defect or difficulty.

For convenience we shall divide them into three main groups:—

a. Cases showing marked anteroposterior malrelationships, Angle's Class III and Class II.

b. Cases in which the speech defect arose from the malposition of an individual tooth.

c. Cases with lisps.

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* This question of the balance of intra- and extra-oral muscle forces is also discussed by Winders, A. V. (1956), *Amer. J. Orthodont.*, **42**, 645.

Group A.

Case 1.—Female, aged 16. The patient had a severe Angle's Class III malocclusion (*Fig.* 6 A), which was more marked occlusally than the profile view suggested. The patient was anxious concerning her appearance, talked little and retired to her bedroom when visitors called. She said she had little social life and that her friends stated that she had a lisp. When she talked for any period her speech became indistinct.

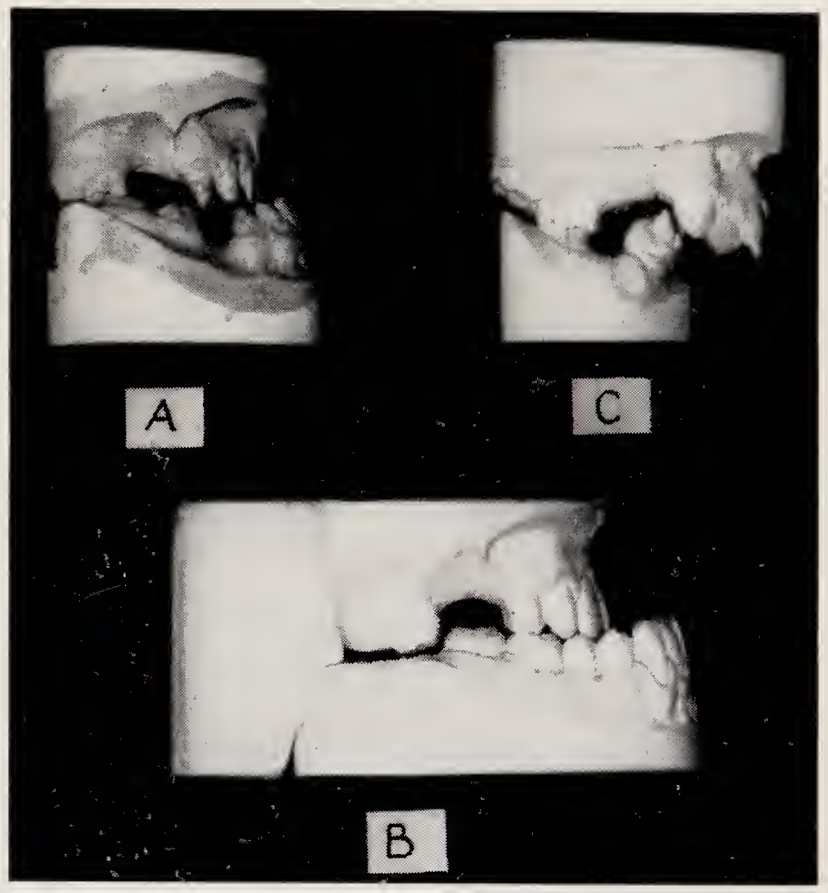

Fig. 6.—A, *Case* 1; B, *Case* 2; C, *Case* 5.

The articulation of the S sound was made with the blade of the tongue, the tip being placed behind the lower incisors as in *Case* 2 (*see below*) (*Fig.* 7 C). The sound was not as distinct as we usually expect.

The labiodental fricatives F and V were produced by a compensation where the lower incisors articulated with the upper lip (*Fig.* 7 A), the reverse of the normal articulation. The patient showed an unfavourable combination of a severe malocclusion, in itself calling for considerable compensation, with a morbid sensitivity which produced an unfavourable emotional state for the overcoming of her handicaps. She was referred for surgical treatment.

Case 2.—Male, aged 25. The patient had a severe Angle's Class III malocclusion (*Fig.* 6 B). He was an intelligent man who was considerably embarrassed by his appearance. His speech to the lay ear did not present any marked defect.

A study of his speech sounds showed several interesting compensations. The labiodental fricative was produced by the normal contact of the upper incisors and lower lip, although this entailed a marked retraction of the lower lip upwards and backwards over the lower teeth (*Fig.* 7 B). We might have expected a compensation similar to that in the previous case.

The S sound was produced with the tip of the tongue behind the lower incisors and a shallow grooving of the blade and front of the tongue to produce a channel (*Fig.* 7 C). The S sound was slightly indistinct.

The linguo-alveolar plosive T was made with the front of the tongue, the tip being placed behind the lower incisors and the blade bunched up in front of the upper incisors (*Figs.* 7 D, 8).

Treatment by orthodontic means was not possible and surgical correction was successfully carried out by

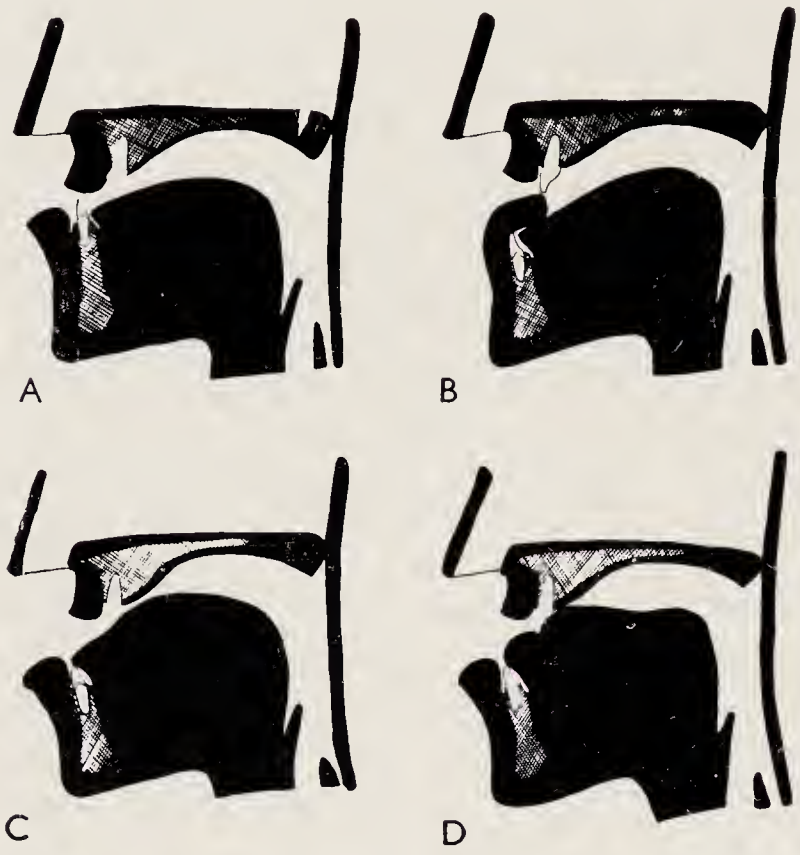

Fig. 7.—A, *Case* 1, reverse of normal labiodental contact. B, *Case* 2, normal labiodental contact despite adverse physical relations of parts. C, *Case* 2, substitution of the blade of the tongue for the tip to make S sounds. D, *Case* 2, blade of tongue bunched up to substitute for the tip to make sound T.

Fig. 9.—*Case* 5. Labiodental substitution for bilabial contact.

Dr. W. D. McLennan, to whom we are indebted for the post-operative records. Speech after the operation was normal. He did not notice any conscious adaptation of the tongue to make the S and T sounds distinctly and with the acccpted articulations.

The two preceding cases were of severe mesio-occlusion in adults. The next two are in children and they again illustrate the all-important part played by the intelligence of the patient in obtaining a satisfactory compensation.

Case 3.—Boy, aged 7 years. Marked Class III of doubtful prognosis; there was no obvious speech defect. His intelligcnce was good.

Fig. 8.—*Case* 2. Clinical picture of tongue position when making sound T.

Case 4.—Girl, aged 6 years. Marked Class III with speech defect. The patient had been taking thyroid extract since 3 months of age. General intelligence was poor and she had been having speech therapy. Orthodontically little progress was made until the eruption of the permanent incisors, which are now in an improved relationship but there is slight anterior open bite. The speech is greatly improved. How much of the improvement is due to the speech therapy, orthodontic treatment, or development we cannot say.

Case 5.—Boy, aged 12 years. Angle's Class II, Div. 1 with recessive mandible and excessive overbite, a short upper lip with the lower lip lying behind the upper incisors (*Fig.* 6 C). The bilabial plosives B and P were replaced by a labiodental plosive to compensate for his inability to close the lips together unless with considerable conscious effort (*Fig.* 9). He had a lisp, which is still present. His general intelligence was above average.

Case 6.—Girl, aged 16 years. Angle's Class II, Div. 1, marked proclination of upper incisors, incompetent lips, speech much poorer than in the previous case. A similar compensation was used for thc bilabials as in the previous case. S, T, and Th sounds all defective; the patient had a poor general intelligence and was apathetic about treatment.

Group B.—

Case 7.—Male, aged 17. Angle's Class I. Patient gave a history of difficulty in making his S sound. About one year previously he had noticed that while his S sound was normal during slow speech or short sentences, he would occasionally expcrience "an escape of air when speaking quickly or for long periods". Intra-oral examination showed the presence of a supernumerary tooth behind the rotated upper right central incisor. This extra tooth had erupted within the previous year (*Fig.* 10). It would seem that while the tongue was able to compensate for the malposed tooth during slow

speech, it was not always possible to place it correctly when greater effort was required.

Extraction of the tooth removed the difficulty. The patient also complained that the tooth interfered with his bagpipe playing; some of our English friends may consider this would have been a good reason for leaving it *in situ*.

Fig. 10.—*Case* 7. Palatogram of S sound; note broad airstream channel and supernumerary tooth behind incisors. (The normal palatogram for S shows a narrow channel behind the incisors.)

Case 8.—Female, aged 32. The patient, a professional singer, came for orthodontic consultation with an unusual complaint. During the singing of certain sounds her upper and lower incisors came into contact, causing considerable embarrassment and pain.

Intra-oral examination showed the upper right central incisor to be non-vital, an apicectomy having been done ten years previously. Investigation showed the trauma to the incisors mainly occurred during the singing of German songs and then only during the pronunciation of T and D. At this time, the incisal edge of the upper right central came into sudden and painful contact with the lower incisors. The recent onset of the complaint together with the statement that the upper teeth had once been "straight" led us to suspect drifting and collapse of the arch. A temporary improvement has been obtained by moving the upper right central incisor labially with a removable appliance worn only at night, and maintaining the position with a retainer.

Case 9.—Boy, aged 6 years. Angle's Class I with left upper central incisor in lingual occlusion. There was a marked lisp. No history of onset could be obtained. The parents were not conscious of the speech defect, so it was assumed that the lingual incisor was not the primary cause. The palatogram shows it to be an obstacle to correct tongue placement. The tooth was moved over the bite; a palatogram taken six weeks later showed the lisp still present but improving. Speech therapy was commenced and the defect is now almost corrected.

Case 10.—Girl, aged 8 years. Angle's Class I with Class III tendency. The upper left central incisor erupting lingually, there was a lisp which corrected itself approximately six months after the labial movement of the incisor.

Group C.—The third group had lisps, the speech defect most commonly held to have an intimate connexion with the condition of open bite and associated tongue habits.

We have just included in the two previous sections three cases of lisping, one a marked disto-occlusion, one a neutro-occlusion, and one a neutro-occlusion with a tendency to mesio-occlusion. We have also previously recorded patients with excessive overbite (Angle Class II, Division 2) and normal occlusion with lisps. (Hopkin and McEwen, 1955.)

Case 11.—Girl, aged 16 years. Angle's Class I anterior open bite with tongue-thrusting and a marked lisp. The open bite was closed with fixed appliances incorporating intermaxillary elastics between the upper and lower incisors. The patient has maintained this occlusion for 3 years. She was very conscientious and it is uncertain how much success was due to conscious control. There is still a tendency to tongue-thrust, but the lisp has been corrected and only appears rarely in moments of excitement.

Case 12.—Boy, aged 13 years. Angle's Class I anterior open bite with tongue-thrusting and history of thumb-sucking. No speech defect.

Case 13.—Girl, aged 9 years. Angle's Class I with anterior open bite and tongue-thrusting. History of finger-sucking. The patient had a marked lisp; the palatogram shows a broad channel. Treatment with a fixed palatal grid has cured the sucking habit, the bite is nearly closed, but the lisp and tongue-thrust are still present. [This patient was seen again in January, 1957. The lisp has disappeared but the bite is still open slightly with the tongue-thrusting habit still present.]

Speech Defects and Occlusion.—With the co-operation of the Chief School Medical Officer we were able to examine school children attending Speech Therapy Clinics in Edinburgh.

One hundred and one children between the ages of 5 and 15 inclusive were examined. The results are summarized in *Tables II* and *III*.

Occlusion (*Table II*).—Fifty-three, or just over half of the children were classed as normal. These included a large number of children who showed premature loss of one or more deciduous molars and were therefore potential Class I malocclusions. There were only 2 cases of neutro-occlusion with anterior

open bite. A cross-bite of the cheek teeth was present in 3 children. Apart from 6, the remainder of the children were classified (Angle's classification) as follows:—Class I, 23; Class II, Division 1, 13; Class II, Division 2, 1; Class III, 5.

Sigmatisms: (*a*) Interdental or lisps; (*b*) Anterior sigmatism;* (*c*) Lateral sigmatism.
Dyslalia.
Idioglossia.
Stammer.
Nasality.

Table II.—Speech Defects and Occlusions according to Age Groups

Age	No. in Age Group	Occlusion								Speech Defects								No. of Children more than one Defect
					Angle				Cleft Palate	Sigmatisms			Dyslalia	Idio-glossia	Stam-mer	Nasal		
		Normal	Neutro Open Bite	Neutro Cross-bite	Cl. I	Cl. II D.1	Cl. II D.2	Cl. III		Lisps	Anterior	Lateral						
5	4	3	—	—	—	—	—	1	—	2	—	—	4	—	—	—		2
6	27	16	1	—	7(1)	2	—	1	—	4	—	1	15	4	3	4		4
7	14	10	1	—	3	—	—	—	—	1	—	1	11	1	1	2		3
8	14	7	—	2	2	1	1	—	1(2)	1	1	2	9	—	2	—		1
9	13	6	—	—	4	2	—	1	—	1	1	—	4	1	7	1		2
10	13	5	—	1	2	5	—	—	—	2	—	4	3	—	5	—		1
11	4	1	—	—	2	1	—	—	—	1	—	—	1	1	3	—		2
12	8	2	—	—	3	1	—	2	—	3	—	1	2	—	2	—		—
13	3	2	—	—	—	1	—	—	—	—	—	2	1	—	—	—		—
14	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		—
15	1	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—		—
	101	53	2	3	23	13	1	5	1	16	2	11	50	7	23	7		15

(1) Includes two cases of cleft palate.
(2) Insufficient teeth for classification.

The Class I cases included 2 cases of cleft palate, whilst a third cleft case was unclassifiable. It will be seen that if the cases characterized by anteroposterior malrelations are excluded, that is Angle's Class II and III, totalling 19 children, the remainder, comprising 82 children, had a normal anteroposterior relationship of the jaws.

Speech Defects.—These were recorded as follows:—

We were interested to see whether there was any association between a particular defect and a particular malocclusion, such as a relationship between open bite and lisping, and also whether the incidence of certain defects lessened with age.

Table III lists the types of occlusion present in the defects under treatment. The

Table III.—Types of Occlusion found with Various Speech Defects

Speech Defect	Occlusion								Total Defects
	Normal Occlusion	Neutro Open Bite	Neutro Cross-bite	Angle's Classification				Cleft Palate	
				Cl. I	Cl. II, D.1	Cl. II, D.2	Cl. III		
Lisp	7	2	1	2	3	—	1	—	16
Anterior sigmatism	—	—	—	1	—	1	—	—	2
Lateral sigmatism	4	—	1	1	5	—	—	—	11
Dyslalia	33	—	1	10	3	—	3	—	50
Idioglossia	2	—	—	2	3	—	—	—	7
Stammer	9	—	1	9	3	—	1	—	23
Nasality	2	—	1	2	1	—	—	1	7
	57	2	5	27	18	1	5	1	116

* A defective S sound not a lisp or lateral sigmatism.

table shows that, in general, speech defects were as likely to be found with normal occlusions as with malocclusions. The disto-occlusions (Angle Class II) cases were representative of the anomaly varying from mild to severe; the mesio-occlusions (Angle Class III) were of a mild to moderate degree. The defects of particular interest to us were the lisps and dyslalias.

To take the dyslalias first; these predominated in the younger age groups. Up to, and including 8 years, 39 out of 59 children had a dyslalia; the remaining age groups show only 11 out of 42 children with a dyslalia. As we have briefly suggested in our previous paper, we thought that there might be a variation between developmental age and chronological age in speech development analogous to variations in dental age and chronological age. We further thought that this association of speech with dental defects was possibly not one of cause and effect but coincidence, and that in both cases some of the defects would clear with further development.

Our figures suggest that this may be so. No one would suggest that pre-school children who say "fink" for "think", and "dese" for "these", require formal speech therapy. They are having natural therapy from their environment, and as they develop in intelligent perception and discrimination together with increased dexterity and control of the speech organs, their dyslalias disappear. It is not hard to imagine a child of 7 whose development of intelligence is on the slow side and has the intelligence of the average child of 5, showing lack of consonantal mastery, which at 9, with the intelligence of a 7-year-old child, he had acquired. At the same time at 7 he may show an incisal irregularity and spacing which at 9 has corrected itself.

The transient anomalies of the "ugly duckling" stage we are all familiar with. Pollitt (1949) eliminated from treatment dyslalic children between 5 and 7 years of age with I.Q.s of 70–85 with no organic abnormality and who had been making slow but steady progress. Keeping these children under observation she found 6–12 months later that they were all either normal or improving. We wish to stress that this is of course only one aspect of the causes of dyslalia whose association with our own subject we feel justifies us in invading the aetiological field of speech defects. Turning now to discuss lisps we must fortify ourselves with C. P. Scott's dictum: "comment is free; facts are sacred". We will present our facts as we observed them and then make free with our comments.

In our orthodontic cases we have shown lisps present in malocclusions varying from excessive overbite to open bite and antero-posteriorly in mesio-occlusion, normal occlusion, and disto-occlusion. As regards tongue habits only some of our lispers were tongue-thrusters. On the other hand one of our patients, as you saw, had an anterior open bite, tongue-thrust with an atypical swallow, and normal speech. Our speech therapy cases showed a similar variety of occlusions, with 7 out of 16 children showing normal occlusion and only 2 had anterior open bite with tongue and thumb habits, while atypical swallows were noted in 4 children. At the other extreme 1 child showed a normal occlusion antero-posteriorly with an excessive overbite, and a normal tongue action and lip posture.

One case was of interest—a boy of 12 years who had fractured the mesial edges of his upper central incisors, leaving an open space. The speech therapist thought this to be the cause of the lisp and felt confirmed in her diagnosis by the speed with which the lisp was corrected—in less than a term.

Six children had dyslalias in addition to a lisp and 1 boy had a stammer. One of these dyslalic children had high-frequency deafness, stated by Curry (1940) as a cause of lisping.

We now consider the relationship of lisping to malocclusions and tongue habits. Bernstein (1954) found a strong relationship between open bite and lisping, although the severity of the lisp was not related to the degree of open bite. Van Thal (1954) stated that dental irregularities are not the cause of lisping. The two conditions may have a common cause which "must be sought elsewhere, either in the neuromuscular system or in a psychological condition". Curry (1940)

expresses a similar opinion when he says that "lisping may occur as a purely functional disorder of psychogenic origin; imitation may also play a part and, like stuttering, it may vary with the physical health and the psychological situation". Lisps have been reported as occurring temporarily following the loss of the deciduous incisors and before the full eruption of their successors.

We can therefore place lisps into four groups:—

1. Those associated with auditory defect.
2. Those due to imitation.
3. Those arising in previously normal speakers, such as the patient shown earlier with the erupting supernumerary or the boy with the broken incisors; here the tongue is like a person moving in a familiar room in the dark where, unbeknown to him, the furniture has been rearranged, with resultant confusion in established patterns of movement.
4. Those of a neuromuscular or psychogenic origin.

It is this group which is of especial interest to orthodontists and speech therapists, as it is thought by both that in the behaviour of the tongue we have a connecting link between some forms of malocclusion and lisps. The works of Rix (1946) and Gwynne-Evans (1951, 1952) and Ballard (1953) in this field are well known. From discussions with speech therapists, and in particular with Miss Barnes of the Wester Lea Residential School for Spastics at Edinburgh, we got the impression that they believe that frequently in lispers the tongue appears to come too far forwards and that this is due to a tongue-thrust. Our observations do not wholly support this view, but we feel that at the moment there is some confusion on the subject of tongue-thrusting owing to the great amount of study being carried on and the modifications of views that are taking place; for instance Gwynne-Evans would appear to differentiate between two types of tongue protrusion, whilst our President Hovell (1955) lists three types of atypical swallow. Ingram (1956), in a personal communication, stresses the difference between the rooting reflex and the infantile swallow. In his opinion, based on his pædiatric and neurological experience, it is unusual to be able to produce true tongue protrusion after the age of nine months, apart from cerebral palsy cases where immature reflexes tend to persist because of slow development or in cases of mental defect. On the other hand the infantile form of swallowing may persist for a very long time—for life in cerebral palsy cases. He suggests that mental defect, cerebral palsy, and emotional retardation may be causes of both the speech defect and the persistence of the infantile swallowing pattern. In his view we do not yet know enough about the subject to give any opinion.

Apart from the abnormal pattern of tongue behaviour in swallowing there is also a further aspect of the neuromuscular mechanism to consider. This is the complex question of the development of muscular positional sense and control. It would appear that there are children who have a clumsiness in carrying out the delicate movements required for speech which may or may not be evident on examination (Morley, Court, and Miller, 1954 a, b, 1955, 1956). While we would accept the evidence of more competent observers than ourselves that one cause of lisping may be associated with some type of atypical swallowing, our observations of four dyslalic children suggested to us that some lisps are perhaps no more complex in origin than other consonantal substitutions, that they are in fact a dyslalia and are due to imperfect tongue control or faulty perception of tongue position. One child showed a forward progression with, for example, T for Ch (tip for chip) and Th for S. The other three children showed among other dyslalias the substitution of S for Th, that is the reverse of a lisp. One of these three had an atypical swallow with tongue-thrusting. We realize of course that these observations will be familiar to speech therapists, but we felt they might be of interest to our fellow members who, when the subject of lisping is discussed, tend naturally to hear mainly of its relationship to tongue-thrusting.

Finally, we must briefly refer to the psychological aspect mentioned by Van Thal (1954) and Curry (1940). This raised the interesting question of the emotions and the tongue and

facial musculature. Van Thal calls attention to the various tongue and lip movements to be seen when under emotional stress. We ourselves saw an adult patient of Miss Barnes's under treatment for lisping who tended to relapse under stress.

Why we should push our tongues forward as children when concentrating is a question we cannot answer, but clearly the influence of the emotions in the causation of speech defects such as lisping has to be considered and conceivably also in the aetiology of malocclusions where the tongue plays a causative role.

GENERAL SUMMARY AND CONCLUSIONS

We have considered two of the organs of speech, the lips and the tongue, which also play an important role from the orthodontic standpoint; we have tried to show that their recent evolutionary history has been influenced in part by the development of speech. We suggest that the increased mobility of the tongue, and the alterations in the balance of forces closing and opening the rima oris that have occurred with the development of speech, may be factors of aetiological significance in orthodontics.

We have discussed and illustrated the dental aspects of the mechanics of speech; investigation of the tongue pressure in certain speech sounds has been shown to be well within the range of pressures exerted in swallowing.

Our further clinical observations have confirmed the opinion formed in our preliminary report that while in the majority of cases malocclusions are not the cause of speech defects, there are occasions when the malocclusion is the exciting cause of the speech defect. There are, broadly speaking, two sets of circumstances where this is so.

Firstly, in cases of speech defect arising in previously normal speakers. Here the accustomed movements of the tongue are interfered with as in the patient with the erupting supernumerary or there is an alteration in the arrangement of the teeth as in the case of the singer, or there is sudden loss of tooth substance affecting the size of the air stream channel as in loss or fracture of the incisor teeth. Although not strictly within our field, the speech difficulties encountered by patients with dentures are of a similar nature.

The second set of circumstances is that in which there is a severe anteroposterior malrelationship of the jaws, calling for marked compensations, the extent to which these are accomplished depending on the intelligence and psychological well-being of the patient, as was illustrated by the cases of severe mesio- and disto-occlusion which we have shown.

With regard to the relationship of tongue habits and lisping we think that further research is required and that the questions raised are ones for those concerned with the neurological sciences.

Acknowledgements.—We have pleasure in acknowledging the considerable assistance and helpful advice we have received in preparing this paper both from our colleagues in the University and from speech therapists in Edinburgh. We wish to thank Miss J. Barnes, Miss K. Morrison, and Miss S. J. Nelson and her staff for their ready co-operation; Mr. D. Abercrombie for advice and references on phonetics; Mr. C. H. Kemball for anatomical criticism; and Professor D. Whitteridge for guidance and facilities for experimental work. We also wish to thank Mr. D. C. Standen, Clinical Dental Photographer, for the illustrations.

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DISCUSSION

Miss J. H. Van Thal said that Mr. Hopkin and Mr. McEwen had made it clear that for speech the mobile parts were more important than static structures. They were discussing speech in its narrower sense, that was to say articulation, and leaving out of consideration the voice and the wide concept of language, namely the use and comprehension of words. The speakers had shown that for adequate articulation the sense of hearing, intelligence, and psychological conditions bore as great weight as, or even greater weight than, the neuromuscular aspects.

The tactile sense and kinesthesis must not be forgotten as having a big part to play in the acquisition and use of correct articulation; nor must vision be overlooked.

Skill in learning to speak one's mother tongue and other languages was based partly on specific endowment and would vary according to whether one more readily responded to visual or auditory stimuli, whether one's tactile sense and proprioceptive sensations were highly evolved or not.

A speaker might have to adapt to unpropitious oral formation, present from infancy or which might have been acquired in early childhood; he might have to adapt to an acquired and irremediable condition; or he might have to adapt from a one-time unpropitious condition, which had been remedied, to a new and more propitious but unfamiliar one after habits of speech had been established. Success in adaptation depended not only on auditory and motor skill but largely on the speaker's intelligence and character. Later she would play a recording of a patient without a tongue who had also had part of the mandible excised because of carcinoma. He had strong motivation to speak again, he was intelligent, an audile type, courageous, determined, and optimistic. He had been given a short explanation of what was required, and he had done the job for himself.

The case of the boy with the supernumerary tooth illustrated failure to adapt to a new situation once speech habits were established; but there was absolutely no need for the boy to adapt, because he had every right to expect the hindrance to be removed, as it was.

Although prosthetics were not within their purview at the meeting, she could not refrain from saying that here the question of adaptation also arose and it was just as important from the point of view of speech that a prosthetician should bear speech habits in mind. A speaker should not have to adapt to his prosthesis provided his speech was normal. That opened up another question for consideration by the orthodontist. Did a patient have to adapt to an orthodontic appliance and then readapt to being without it? Her point of view was that if he were to speak with a mild defect while wearing the appliance, she would leave it thus.

There were two issues which she wished to raise. One was the statement that the SH sound was made with a flat tongue. It was not made with a flat tongue; the channel was much shallower than for S, and the tongue was drawn back from the anterior alveolar ridge. A flat tongue would give rise to the alcoholic type of S or SH—or a sound normal in Chinese but not in English. A palatogram would show contact farther back; a flat tongue gave a different sound.

She queried the term "anterior sigmatism", which was unfamiliar to her although she served on the terminology committee for her specialty.

Lakermance in 1948 wrote that there was little connexion between the daily practice of the stomatologist and the phoniatrist except for cleft-palate cases. On the other hand, Froeschels and his associates had stressed the affinity between chewing and speaking, and it was about fifteen years ago that Professor C. Ballard had asked her to co-operate with him in investigating muscle balance in relation to orthodontics. The meeting had shown that Lakermance had taken much too narrow a view.

She was very happy to find so great an interest taken by the orthodontics profession in a subject-matter which was one of prime interest to her.

Miss Van Thal's recording was then played, and she added that the patient had been a lecturer on recorder playing and had played the recorder again.

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Professor C. F. Ballard congratulated Mr. Hopkin and Mr. McEwen upon producing an excellent paper from the point of view of both their clinical observations and their review of the literature. It was a very valuable review and formed a basis on which discussions could take place in the future.

The condyles were anchored in the glenoid fossa with a 1·5-m. stainless-steel wire passing through the cheek and into a hole drilled in the ramus just below the sigmoid notch.

The outer end of the wire was attached to an insulated wire fixed to a splint cemented to the upper teeth. The ramii were then sawn through and the larger fragment of the mandible pulled forward and ligatured into correct occlusion with the mandible.

Mr. H. E. Wilson asked whether in the so-called normal occlusion cases or in healed cases, with speech defect the authors had investigated the free-way space. He had observed that a large free-way space was frequently associated with them.

Another point which had occurred to him was the difference in size and shape of tongues in relation to dental arches. Could the large tongue be accommodated in the smaller dental arches? If not, did it affect speech?

It appears that at times the neuromuscular mechanism could not overcome this disproportion between tongue and dental arches and produce a normal tongue behaviour and normal speech.

Mr. J. R. E. Mills thanked the authors for a most interesting paper on a subject about which he was sadly ignorant.

He had understood Mr. Hopkin to say that the sigmatism was associated with a number of different types of malocclusion, and was not specific to any one type. He wondered if this was due to lumping together several quite different defects and calling them all "sigmatism". He had no expert knowledge but felt he could himself distinguish at least two types, if he was presented with recordings of them; on the one hand was the type associated with a persistent thrusting forward of the tongue, and with an anterior bite. On the other was a more sibilant type, associated with a protrusion of the upper incisors, but with a deep overbite. There might well be other types.

Mr. W. J. Tulley asked whether the authors had studied family histories in relation to the speech defects of the kind which had been mentioned. He had been intrigued by what they had said about the tongue rolling and the mobility of the tongue. There was a familiar factor here.

With regard to tongue sensations, there are no proprioceptive impulses from the tongue muscles. Did tongues vary in their sensitivity to contact and stimuli?

Mrs. M. Michaelis said that she was very interested in the question of lisping.

Miss Van Thal seemed to think that there was not much connexion between lisping and orthodontics—should she say?—irregularities. She could think of an adult who had lisped slightly all her life. The case was a very prominent Class II, Div. 1, with the lower incisors biting well into the palate. A periodontal splint was made for her. It had a platform behind the upper teeth. There had been no mention at all of the lisp; neither the patient nor she were particularly interested in it, for it was mild. However, within a short time of wearing the periodontal splint the patient stated with surprise that she no longer lisped, and the absence of lisp persisted even when she removed the splint. That was quite accidental; there was not intentionally any connexion between the lisp and the splint. The splint was put in entirely for periodontal treatment.

She wondered whether that was common or unusual. She knew only of the one case.

The Chairman said that the meeting had listened to a discussion which was perhaps not as extensive as the paper had deserved, but that always happened when new things came to them. They had to have time to read them and absorb them and think about them before they could discuss them. That was how he had felt about the paper. He found it most interesting, but he also found that he needed a little more time to consider it before he got up and made a fool of himself in public—with apologies to those who had taken part in the discussion!

The paper had shown what an immense field had been opened up by the present-day approach in orthodontics to the orofacial patterns and morphology. It had emphasized how little they actually knew about those things, about their aetiology, the part played by intelligence, by psychological factors, by morphology itself, by innate genetic factors, and all the other factors which Mr. Hopkin had mentioned. He had been very pleased to listen to the paper and broaden his mind a little.

He invited Mr. Hopkin and Mr. McEwen to reply to the discussion.

Mr. Hopkin, replying to the discussion, said that he and Mr. McEwen would like to thank Miss Van Thal for dealing so gently with them. She had been very kind and forbearing. He was sure she might have shot them down far more than she had.

With regard to the question of compensation, he was glad to find that they were in agreement on that point and had taken the right view that it was the ability of the movable parts to compensate for the defects of the rigid parts.

He had been very interested in Miss Van Thal's recording. Patients like the one in question were deserving of very real admiration for the very courageous spirit which they showed in overcoming such a terrible deformity.

The question had been asked: Does a patient have to adapt to an orthodontic appliance? The authors ought to have mentioned that, but there were many things that one tended to overlook. It was part of their standard advice on giving a patient an appliance to tell him that he would find it a little diffieult to talk at first but that after a few days he would talk quite well with it and that he would have the reverse difficulty when he left the plate out. They had not had any serious complaint on that score. After a few days all the patients said that it was all right. One of his own children had been provided with an appliance, and for one meal they had had peace!

With regard to terminology, he must take full responsibility for the use of the term "anterior sigmatism". Probably it came out of his mind and not out of speech therapy.

He thought that the authors and Prof. Ballard werc really in agreement. To some extent there might be misunderstanding. He had been confused as he did not think he had ever found a really firm definition of "incompetent". Prof. Ballard had said that he did not regard it as an abnormality. He would agree, but he would ask Prof. Ballard whether an oraseal was really neeessary. He was curious about that.

Prof. Ballard had referred to the development of the chin as a speech modification. He thought there had been a *lapsus linguæ* on the part of Prof. Ballard. Had Prof. Ballard meant to say "chin"? He himself had not said that; he had mercly mentioned it as an exploded theory. He had always felt that the primary change must be in the morphology, and then, with favourable cireumstanees, speech or whatever it was developed.

He thanked Mr. Watkin for his very kind remarks and appreciated his being with them. Mr. Watkin had referred to a case which he said was a gross Class II and not Class III. The authors had not met a case of such degree, but one of those shown on the slides had been like it. However, he had not met sueh a case, and it was very interesting.

Mr. Watkin said that the patient was 22 years old.

Mr. Hopkin said that Mr. Wilson had raised a query about the free-way space in normal or corrected cases. The authors had not observed the free-way space. They would certainly take notice of that point in future.

The remarks that Mr. Wilson had made about the shape and size of the tongue and the absence or presence of proprioceptive fibres underlined the points that Duckworth made on the need for further basic research into the structure of the tongue, both anatomically and physiologically.

Miss Van Thal might be able to elucidate the point raised by Mr. Mills, for she had mentioned the question of the differentiation of interdental lisps. He could not say that the authors had observed it, except for what they had described as an indistinct S in some of their Class II, Div. 1 eases.

Miss Van Thal said that the tendency was to label sigmatism according to the manner of formation of the substituted sound but sometimes according to the acoustic effect.

There was a substitution for S which approximated to F and was halfway betwecn F and TH, which they called labiodental sigmatism. There was the out-and-out substitution of TH known as "interdental sigmatism" and a mild kind which gave the same effect. There were also the strident (whistling), lateral, the diffused sigmatism (made over a flat tongue. the alcoholic's sound to which she had referred earlier) and the substitution of other fricatives. There was an immensely wide variety of this type of consonants. However, the diffused and lateral sigmatism, the interdental types, and the labiodental sigmatism together with the strident sigmatism were those of most interest to the present assembly.

Mr. Hopkin, thanking Miss Van Thal for her dramatic illustration of the types of lisp, said it was obvious that Miss Van Thal should have been giving the paper.

As to studying families in relation to tongue rolling, he had discusscd the subject with Mr. Abercrombie, and he believed he was right in saying that the ability or otherwise to roll the tongue was now accepted as being due to hereditary factors.

Mrs. Michaelis had made a most interesting observation. The authors had not come across anything similar to that. There was only one thing in that line at all, again discussing the question of lisps. He had diseussed the matter with Mr. Abercrombie, who said that in the case of some people it was just their way of doing it and that was the way they were going to do it. Mr. Abercrombie had told him a story of a young lady being taught some African dialect by Mr. Daniel Jones. When she went to him he was horrified to find that she had a marked lisp. He introduced hcr to the S sound in the dialect and she did it perfectly. When hc revealed to her the secret that it was the normal S sound which she was making in the dialect she said she would do it in the dialect but not in English, and she persisted with the lisp in English. Thcy also had the example of Sir Winston Churchill and his speech idiosyncrasies. With some individuals it was part of their gimmick and they just did not want to lose it.

He eould not give any explanation about the lisping lady whose lisp was cured by the splint, and he would invite Miss Van Thal to give her views on that.

Miss Van Thal said she understood that the patient mentioned by Mrs. Michaelis was 36 and so she had a long-established speech habit. The splint forced her to adapt. The remarkable thing was that she did not revert to her old habits. She thought the patient was a somewhat unusual person who had not known how to adapt, and the splint helped her.

Mrs. Michaelis said that the patient wore the splint permanently, and it was only when it was out momentarily that she found that she did not lisp now.

Miss Van Thal said she thought that Mrs. Michaelis's patient was a very unusual person.

Mr. Hopkin said he agreed with the President about aspects of the pars peripheralis and marginalis, but with regard to the width of the field of study it might be of interest to know that Curry in his book said that it took him eight years to cover all the ground that the field covered. So it was an enormous gold mine in which they could all, he hoped, dig with profit.

It might interest the younger members to know that he had come across the saying "A lisping lass is good to kiss". He did not know whether that had anything to do with the tongue-thrusting habit! (*Laughter.*)

Mr. McEwen, also replying to the discussion, said that when the boy with the supernumerary tooth came to the authors he did not associate the supernumerary tooth with his speech defect.

So far as orthodontic appliances were concerned, he would make a plea for closer co-operation between the speech therapeutist and the orthodontist.

With regard to the point about the SH sound and the Chinese, he could only hope that his university would give him a little money to investigate it.

He was glad to hear that there was a terminology committee. The authors had had a certain amount of difficulty digging into the terminology which they used.

With regard to Mr. Tulley's remarks about the rolling of the tongue, they started off in the orthodontic department to see how many people could roll their tongue. He was the only one who could not. Then they moved to the hospital, and again he was the only person who could not roll his tongue. So they had decided that it was rather abnormal.

A vote of thanks to Mr. Hopkin and Mr. McEwen, proposed by the President, was carried by acclamation, and the meeting then terminated.

NATURE AND NURTURE IN JAW DEVELOPMENT

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INTRODUCTION

THE purpose of this lecture is to review some of the recent research that has been concerned with experimental interference in the morphogenesis of the jaws, and to a lesser extent with that of those solid secretions of the skin that embellish them—the teeth. I would like to consider especially some recent experimental work on teratogenesis, and as one interested in the placenta to emphasize that because of what may *not* pass across it, or what may traverse it abnormally or in excess, the fœtus, and even the orthodontist as he later tends the aged fœtus's teeth and jaws, should have much respect for this potentially dangerous organ. I think that there is much of interest and of significance to you, in the implications of this experimental causation of malformation.

The interest in the effects on the embryo and fœtus of teratogenic agents has been considerable and is rapidly increasing. It is now well established that experimentally produced alterations in the embryonic environment are capable of bringing about the appearance of characters of a particular genotype in an animal endowed with a different genotype. What has only been realized recently is that, quite apart from the action of what may be considered truly toxic substances, quite subtle alterations in the amounts of normal nutritional and hormonal substances reaching the vertebrate embryo can frequently have remarkable and diverse results of a distinctly disadvantageous nature. It is also clear that the alteration in the environment is only effectively teratogenic at a certain time in embryonic development, and as the academic embryologist establishes the successive horizons in the embryo's life the better will the mechanism of interference be understood.

We know that every fertilized ovum possesses a genetic potential, derived from the chromosomes in the egg and the spermatozoon. We believe that, by some mechanism hardly understood, a particular constellation of genes brings about the development of a particular species of animal. We also know that the external environment of the ovary, uterus, and maternal tissues generally is necessary for normal intra-uterine development and for full gene expression. Evidence has been produced that strongly suggests that in many mammalian species, if not all, there are also internal environmental factors operating towards the end of pregnancy—these are factors generated by the fœtus, for example fœtal hormones. Perhaps I might make the point clear by reference to the effect of hormones on fœtuses.

CORTISONE AND ACTH

It is possible to produce cleft palate in the offspring of experimental animals (rats and mice) as the result of administration of the appropriate dose of cortisone at a particular time during pregnancy. The standard teratogenic dose given to pregnant mice by Fraser, Kalter, Walker, and Fainstat (1954) was 2·5 mg. of cortisone acetate daily for four days. The incidence of cleft palate is highest when treatment is started on the tenth or eleventh day of pregnancy; resorption of embryos is then between 13 and 25 per cent. Such doses also cause reduction in litter size and weight of newborn offspring. The genetic basis for susceptibility to this teratogenic action of cortisone is considered by Fainstat and his collaborators to be polyfactorial, depending on the genotype of both the mother and the embryo. Jost (1956) reports that 1–3 mg. cortisone injected directly into the rat fœtus before the sixteenth day of pregnancy causes cleft palate; higher doses, and even doses of this order, often kill the embryo. The incidence of hare-lip in the fœtus is not

Shortened version of The Northcroft Memorial Lecture, given at the meeting held on November 12, 1956.

increased by the administration of cortisone during pregnancy.

Injection of pregnant mice with 5 mg. ACTH every 6 hours for two or three days from the thirteenth day of pregnancy also produces cleft palate, but not as predictably as with cortisone (Fraser and others, 1954). It is suggested that the adrenal cortex of the pregnant animal is the target for the ACTH; the fœtal adrenal is almost certainly not functioning at this fœtal age and there is no evidence that ACTH acts directly on the fœtal palate. This then raises the question of whether stress to the maternal organism may result in the secretion of teratogenic quantities of cortisone and, if so, it would in a way invalidate Corner's statement (1944) that sweet thoughts, sour moods, and tragic emotions cannot cross the placental membrane. It also raises the possibility of fœtal stress, but the human fœtal pituitary is only known to produce ACTH near term and thus long past the time of closure of the palate. Whether cortisone has any direct effect on the developing tooth germ is not known.

There has been much debate as to whether any defects attributable to cortisone have resulted from the treatment of human patients during the sixth to eighth week of pregnancy. De Costa and Abelman (1952) and Christensen, Margulis, and Stewart (1952) review the matter, but point out that seldom is cortisone given between the forty-fifth day, when the palatal processes appear, and when they finally fuse at the twelfth week. Wells (1953) treated nearly 30 patients with vomiting of early pregnancy; 3 of the babies had congenital malformations not attributed to cortisone, none had cleft palate. More recently Harris and Ross (1956) describe a woman who gave birth to a stillborn baby with a cleft palate after she had received a total of 6·05 g. of cortisone over two months early in pregnancy. Subsequent obstetrical history suggested that the cortisone was administered from about the thirty-eighth day of pregnancy and thus continued throughout the period of palatal closure. Another instance of cleft palate in the premature infant of a mother treated with 100 mg. cortisone and 400 mg. tolazoline is recorded from Melbourne in *The Lancet*, 1956, **2**, 730 (Doig and Cottman). Although it cannot be claimed that these two cases indicate that cortisone has a teratogenic effect during human pregnancy, it could not have been bettered as an experimental (in fact accidental) attempt to test the validity of the application of results from the laboratory to man. In the words of A. L. Johnson (1955): "data derived from animal experimentation alone, are not sufficient unto themselves; it is on the common ground on which they meet that facts are found".

The common ground on which these particular experiments meet concerns the mechanism of closure of the two palatal processes, how cortisone and other teratogenic substances may interfere with the mechanism, and why so frequently it is only the palate that is involved and not the other facial regions. Ever since the original descriptions of His (1892, 1901) and the review by Peter (1924) it has been customary to consider the development of the face and jaws as being brought about by the fusion of a number of processes. Streeter (1948) has criticized this view in that it is an oversimplification, and that in reality the processes are not promulgated with free ends that meet together in the facial region, nor is ectoderm ever absorbed over the approximating surfaces. Streeter considered it more proper to speak of the facial processes as swellings or ridges that correspond to centres of growth in the underlying mesenchyme. The furrows presented on the surface of the embryonic face are eventually smoothed out as proliferation and fusion of the growth centres beneath take place. Ectoderm is not absorbed between continuous surfaces of the facial processes, but in fact the furrows become more shallow and eventually smooth out as the increase in mass of the tissue produces new levels. We should therefore abandon the word "process" in this respect and instead use the expression "growth centre", or ridge, or septum, or whatever it may be.

When we turn, however, to consider the mechanism of closure of the secondary palate it is almost impossible to avoid the conclusion that, initially at least, edge-to-edge contact

and fusion must occur. Otherwise it must be postulated that the nasopalatine canal (the incisive canal of adult anatomy) forms as a result of a localized midline breakdown between the primitive palate and the maxillary shelves of the secondary palate, and there is no evidence for this. It may be that there is a later proliferation backwards of the palatal mesenchyme, after the initial fusion of the secondary palate, so ironing out the embryonic cleft.

The mechanisms postulated to explain the embryonic movements of the tongue and palatal shelves have been reviewed a number of times. Downward displacement of the tongue and floor of the mouth, depression of the mandible, forward elongation of the tongue, changes in the form of the tongue and its movements, widening and elevation of the roof of the buccal cavity, have all been considered as forces that remove the tongue from between the palatal shelves. Likewise it has been suggested that the palatal shelves are moved upwards by the pressure of the tongue, by a rapid rotation of the palatal shelves due to some intrinsic morphogenetic movement, by growth changes in the palatal shelves due perhaps to an increase in the intercellular substance associated with connective tissue, or by all three forces (Lazzaro, 1940).

Recently Walker and Fraser (1956) have carefully studied the mechanism of palatal closure in three strains of mice. The movement of the palatal shelves from the vertical to the transverse plane is rapid, occupying about three hours, and only a further six hours or so is required for palatal fusion. It seems clear, however, that the stage is not set for these sudden movements to occur until the fourteenth day. There is no evidence of any rotation of the shelves, rather is there "a bulging of the medial wall and a regression of the ventral wall of each shelf, with the transformation proceeding in a wave-like motion from the posterior ends of the shelves to the anterior ends". It is considered that the shelves move by means of an internal force, and that this is provided by the appearance of a network of elastic fibres in the developing connective tissue of the shelf. Several observers have noticed that the unfused shelves will spring backwards and forwards, but will not remain in an intermediate position. Walker and Fraser (1956) have examined the cytochemical properties of the shelf tissue and have found that with Gomori's aldehyde-fuchsin stain there appeared to be specifically stainable fibres (unstainable after hyaluronidase treatment) in the shelf connective tissue. It would now be interesting to know if cortisone has any observable effect on the cells of the shelf tissue, or on the fibres, or on the fibres with elastic properties; examination with the electron microscope of normal and treated shelf tissue might well give interesting results.

Before finally leaving the question of the effect of cortisone on the fœtus I should like to mention the experiments of Jost (1956) and of Yakaitis and Wells (1956). The experiments involve the decapitation of the rat fœtus while in utero, thus effectively removing the fœtal hypophysis, hypophysectomy of the maternal rat and the implantation of cortisone, hydrocortisone, and DCA under the fœtal skin in utero. The results indicate that the hypophysial-adrenal system begins to function before birth in the rat. This raises the question of whether cortisone has an effect on the fœtus later in pregnancy, and it is interesting that Domm and Leroy (1956) have noticed a precocious eruption of incisor teeth in fœtal and newborn rats following daily injections of 2–10 mg. cortisone during the latter half of pregnancy; 500 gamma injected directly into the fœtuses between the fifteenth and twentieth day of pregnancy caused similar precocious eruption.

ADRENALINE

Jost (1953) has been able to produce in an apparently normal strain of rats, by the administration of adrenaline and other hypertensive substances during pregnancy, anomalies that are characteristically found in the strain of rabbits known as *br* and in the strain of mice *my*. Treatment, given directly to the fœtus in the form of 25 γ by intraperitoneal injection, is carried out on the

thirteenth to fifteenth day of pregnancy and results in amputation of the feet, necrosis of the hands, and marked recession, or failure to grow, of the lower jaw. In part these lesions are due to the formation of areas of local œdema and the development of clear watery blisters into which hæmorrhage can occur later. Jost suggests that in those strains displaying the inheritance of the defects the phenogenetic change between the gene and its expression may be concerned with a physiological mechanism comparable to that causing the experimental results. He then postulates that an overproduction of vasopressin or adrenaline during fœtal life might be the mechanism causing hereditary acroblapsy (the name being given to the syndrome). It is interesting that over twenty-five years ago Sir Arthur Keith suggested that some such hormonal mechanism might well be the cause of the various types of jaw form within a race or group of people.

STRESS

Some investigation of the possible effects of emotional stress during pregnancy in women has been carried out on the Continent (Klotz, 1952), but the interpretation must obviously be treated with caution. Methods of causing emotional stress in experimental animals are difficult to devise; physiological stresses, such as hæmorrhagic anæmia, give dubious results, but Ingalls, Curley, and Prindle (1952) found that anoxia caused cleft palate when applied on the fourth to fifteenth day of pregnancy. Our efforts at obstructing the blood-flow through the uterine and ovarian arteries in rats for short periods of time have resulted in resorption of some of the embryos, but no detectable changes in tooth germs or palate in those embryos remaining alive.

Recent work has shown that the fœtus is by no means as safely isolated from physical shock as has been commonly maintained. The fœtus at 30 weeks responds convulsively to a doorbell buzzer held near its head outside the maternal abdominal wall (Sontag and Richards, 1938) and a startle reflex is easily elicited in other ways. Tapping on the side of a bath-tub in which a pregnant woman is lying causes sudden jumps on the part of the 9-month-old fœtus. Orchestral and piano music, and even the vibration of a washing machine, results in marked fœtal activity during the last two months of pregnancy (Bernard and Sontag, 1947).

INSULIN

Smithberg, Sanchez, and Runner (1956) have been able to produce exencephaly, fusion of ribs, or umbilical hernia in 63 per cent of fœtuses after injecting rats $8\frac{1}{2}$ days post coitum with 0·1 unit (Lilly) of protamine zinc insulin. The dose was sufficient to produce shock, from which recovery was spontaneous.

Recently I have examined a 6-month fœtus removed from a mental patient who had received insulin shock therapy over the first four months of pregnancy. The fœtus appeared perfectly normal.

THYROID HORMONE

Giroud and Martinet (1954) have shown that administration of thyroxin to pregnant rats results in the production of 2–20 per cent of the newborn young with cataract.

TRYPAN BLUE

Wislocki (1920) was probably the first to observe that the dye trypan blue has an effect on the fœtus when injected into pregnant animals. He reported that the fœtuses were undersized and that the dye was stored in the chorio-vitelline or yolk-sac placenta of the rodents he used. Gillman, Gilbert, Gillman, and Spence (1948) first observed the teratogenic powers of the dye; subsequent papers by Waddington and Carter (1952), Hamburgh (1952, 1954), Gilbert and Gillman (1954), Wilson (1955), Myers (1955), and Fox and Goss (1956) have increased our knowledge. The defects produced by the injection of doses such as 0·5–1·0 ml. of a 0·5–1 per cent solution of trypan blue depend to some extent on the time during pregnancy at which it is given (usually after insemination). One of the most obvious features is the production of large, transparent blisters on the body of the embryo, and also of hæmatomata, more usually found in the tail region—both are associated with underlying tissue destruction.

Exencephaly, shortening and other deformities of the tail, deformities of the notochord and somitic mesoderm, defects of the eye and ear and the vascular and urinary systems are present in up to 70 per cent of the living young. Other deformities include reduction of the pinna, imperforate anus, and absence of a genital tubercle. Trypan blue would appear to produce a wider variety of cardiovascular defects (a syndrome of five defects is known) than any other experimental method used to produce abnormalities (Fox and Goss, 1956). The method of action of trypan blue or of the three related dyes that have been tried (Wilson, 1955) is not known: but different commercial preparations of the dye exhibit unequal teratogenic properties. It has been suggested that trypan blue interferes directly with maternal metabolism; that it renders the placental barrier inefficient, or damages it; and that its toxicity or that of any breakdown products (perhaps Hacid) may directly affect the fœtus. As already stated, the dye is observable in the cells of the placenta, but none has been detected in the tissues of the embryo late in pregnancy. Its molecular weight of 960 would be high for the substance to cross the placental barrier easily. Recently, however, Ferm (1956) has suggested that the permeability of the rat blastocyst to azo dyes and other substances is related to the histiotrophic stage of development during the first nine days of pregnancy. He was able to recover trypan blue from the blastocyst fluid of rabbits after the doe had been injected before the ninth day. This just overlaps the time at which injection of the dye has a teratogenic effect, and it is yet another warning to those who like discussing such matters, that the hæmochorial placenta is "efficient" to such an extent that its early tissue-destroying enthusiasm may be disastrous to the fœtus. Trypan blue is not yet known to have affected the jaws or teeth of the developing fœtus.

Other substances besides trypan blue are already known to have disturbing effects on development; they include boric acid, pilocarpine hydrochloride, eserine sulphate, sulphanilamide, colchicine, and azaserine, an antibiotic with tumour-inhibiting properties. Time does not permit discussion of these substances and their teratogenic properties.

DIETARY DEFICIENCIES

It has been known since the early 1920s that a maternal diet deficient in vitamin E could cause the death of the embryo in the rat, but it was not realized until recently that a maternal diet only slightly deficient in certain substances could be the cause of a veritable text-book of abnormalities in the neonate. We know very little yet about the effect of such dietary deficiencies in man, but the experimental results in animals should not fail to be of interest to the dental profession. The dentist, and he is not alone in his troubles, is well aware that prenatal and postnatal influences are so thoroughly intermingled in bringing about the definitive anatomy of the mouth that it is clinically almost impossible to determine the respective roles of all the factors involved. At least the experimental embryologist is nowadays able to present undeniable evidence that a known prenatal factor, or a deficiency of it, can bring about observable abnormalities. Might it not be that the same factor, or one similar, acting at a different degree or level, could produce abnormalities, not so much of shape or form, but of quality?

It is said that Hale (1935) was among the first to notice that the presence of anophthalmia in certain piglets was due, not to any genetic mechanism, but to maternal deficiency of vitamin A. Improvement in the diet resulted in the birth of normal piglets from the same sows that had previously produced abnormal offspring on a deficient diet. A few years later came the important papers of Warkany and his collaborators, and since then evidence of the teratogenic effects of diets deficient in a variety of substances has been presented (Giroud, 1954). No less than seven communications to the last meeting of the American Association of Anatomists were concerned with the teratogenic activities of various dietary and other substances. The subject is now far too large to review here, and I shall merely select a few illustrative examples that might be of interest to orthodontists.

VITAMIN DEFICIENCIES IN THE DIET DURING PREGNANCY

Vitamin A.—Nearly all the common congenital defects that occur in man have been produced experimentally by maternal hypovitaminosis A. Gross defects of varying anatomy of the cardiovascular and urogenital systems are perhaps the most easily produced, but cleft palate, diaphragmatic hernia, retardation in hair growth, narrowing of the optic foramen, anophthalmia and many optic abnormalities, undescended testes and various types of intersexuality, and hydrocephalus have all been found (*see* Giroud, 1954, and Woollam and Millen, 1956, for references). I would remind you also that some years ago Mellanby (1939) showed that lack of vitamin A in the maternal diet can seriously damage the fœtal teeth; the effects on the enamel and dentine of lack of vitamin A must be well known to you.

Do not think that the embryo is safe if vitamin A is added to the diet haphazardly. Giroud and Martinet (1955) have obtained a variety of severe abnormalities, including cleft palate, by administering an excess of vitamin A to the pregnant mother. Treatment of pregnant rats from day 11 to day 13 results in nearly 90 per cent of abnormal fœtuses, with cleft palate being the most frequent lesion.

Vitamin B_2.—Lack of riboflavin was first shown to lower fertility of hen eggs; those chicks that hatch are poorly developed, with short limbs, anæmia, and changes in the liver. Experimental avitaminosis B_2 in pregnant rats produces cleft palate, limb shortening, and fusion of the fingers and toes in the young. The palate is usually cleft posteriorly, without hare-lip, but the lower jaw is frequently shortened, with retarded development of the lower incisors. There is more or less general retardation of ossification (Deuschle and Warkany, 1956) or even arrest at the stage of chondrification; the cartilages are often shortened. This is particularly relevant in examining the relationship of the growth of the mandible (Warkany and Deuschle, 1955) to that of Meckel's cartilage. It could well be argued that the results of these and other experiments indicate a close successional inter-relationship between, first, inductive activities of neural crest cells and thus of Meckel's cartilage, and, secondly, the shortened anteroposterior length of the membranous part of the mandible and the retarded development of the anterior lower teeth. Warkany and Deuschle remark that the experimental mandibular retrognathia is reminiscent of the disharmony seen in children with Class II malocclusion; in an animal with noticeable retrognathia there is a definite reduction of interlabial distance. It may also be of interest that hypoplasia of certain masticatory muscles, in particular the masseter and the mylohyoid, is frequently present in B_2-deficient neonates.

Deuschle and Warkany (1955, 1956) have also found that riboflavin deficiency causes a remarkable series of abnormalities in the facial region of rats. The nasal region tapered anteriorly, the mandible was shortened, the tongue protruded, and varying degrees of shortening of the external nose occurred. The maxilloturbinals and the nasoturbinals are poorly developed and there may be a cleft palate.

Riboflavin deficiency can be accentuated by the addition of the antimetabolite, galactoflavin (Nelson, Baird, Wright, and Evans, 1956) to the diet; abnormalities in a wide range of skeletal components and organs result.

Pantothenic Acid.—Deficiency of pantothenic acid in the maternal diet may result in the birth of anencephalic young, and often there is failure of development of the eyeball (Giroud, 1954).

Pteroylglutamic Acid.—Deficiency of this substance in the maternal diet for a period of only 48 hours any time from day 7 to day 12 of pregnancy in the rat results in the production of 70–100 per cent of abnormal young (Nelson, Wright, Asling, and Evans, 1955). Numerous abnormalities are produced, all bones are dwarfed, in many bones there is retardation or absence of ossification, and there are multiple skeletal defects including cleft palate (Asling, Nelson, Wright, and Evans, 1955). Many of the abnormalities are comparable to those that occur congenitally in man.

Vitamin C.—Lack of ascorbic acid in the diet during pregnancy causes the development in the fœtus of lesions in the mouth and subcutaneous hæmorrhages similar to those of scurvy in the adult.

Vitamin D.—Absence of this vitamin in the diet during pregnancy and deprivation of ultra-violet light cause deformities of the ribs and long bones that resemble those seen in rickets.

Vitamin E.—This was the first vitamin the importance of which to the embryo was definitely proved (Evans and Bishop, 1922), and its absence in the maternal diet causes the placental blood-vessels to degenerate and the embryo to be absorbed. Absence of the vitamin appears to cause hyperplasia of extra-embryonic mesenchyme and thus obliteration of its vessels; it also seems to have a direct action on the fœtal musculature, causing changes in the muscle-fibres and muscular weakness.

Mechanism.—It is generally agreed that vitamin deficiencies disturb metabolic processes in the fœtal cells. It is known that certain vitamins, such as riboflavin and pteroylglutamic acid, are incorporated in enzymes that are essential for normal embryonic development: riboflavin is a component of the yellow respiratory enzyme and pantothemic acid is a constituent of coenzyme A; riboflavin deficiency also results in a diminution of various oxidases. It is known that the distribution of enzymes is not equal in all cells of the fœtus; thus interference in the activities of a particular enzyme may greatly affect some organs and leave others untouched.

OTHER DIETARY ALTERATIONS

It will be obvious why many workers have wondered whether other food substances, administered in excess or deficiency during pregnancy, could have any effect on tooth and jaw structure of the fœtus. Experiments have been devised to see if the offspring of animals treated in such a way have less resistance to cariogenic diets than normal offspring. The literature on this aspect of the results of pre-treatment of fœtuses is growing and work is now in progress: the difficulty is, of course, to translate the results of experiments in animals, in which tooth eruption is often far advanced at birth, to man, in whom tooth eruption occurs so much later and thus in whom the results of the longer action of other factors operating in the mouth, jaws, and skull will complicate the picture. Haldi, Wynn, Law, and Bentley (1955) find that the mineral content of molar teeth of rats pre-treated during fœtal life by a maternal diet of high-sucrose, high-fat, and high-protein content was the same as that of teeth from controls. Preponderance of the major foodstuffs in the prenatal diet does not seem to affect jaw growth or tooth quality. The results of cariogenic diets on the offspring of rats whose maternal diet had been deficient in protein and calcium have been studied by Taketa, Constant, Perdue, and Phillips (1956). Simultaneous lowering of protein to 15 per cent and calcium to 0·2 per cent in the maternal diet slightly altered the susceptibility of the offspring to dental caries. These workers emphasize that it is the nutritive balance that is essential to caries resistance, at least in the species used, and that the cariogenic diets had more effect on the young rat after birth than any alteration of calcium or protein in the maternal diet. The incidence of caries was greatly reduced, whatever the maternal diet, if six weeks were allowed to elapse between weaning and the time of feeding the cariogenic diet. These experiments, and others, sustain the impression that one has to look for deleterious effects of dietary inadequacies or excesses in pregnancy, not as regards the major foodstuffs, but in the quantity of certain particular elements in the constitution of the diet.

The results of withholding food at specific periods (24–40 hr.) during pregnancy in rats have been examined by Runner and Miller (1956) and the highest incidence of anomalies occurred if fasting took place on the ninth day of pregnancy. 28 per cent of fœtuses showed a syndrome of anomalies involving malformed vertebræ, vertebral and costal deformity, and exencephaly. Fasting for 40 hours was incompatible with pregnancy; oral supplements of glucose or amino-acids gave

embryos almost complete protection from deformity. The authors make no comments on the jaws or teeth. Whether there is a clinical lesson to be learnt from such experiments is another matter, but at least these experiments indicate that at a certain critical day deprivation of food can have striking effects on the rat fœtus. At the very least all who are concerned with, or might undertake, animal experiments during pregnancy would be well advised to ponder deeply on matters of diet.

We should here mention that Giroud and his collaborators have found that a diet deficient in folic acid results in the birth of offspring with atrophy of the nasal cavity and hare-lip, among other deformities. Linoleic acid deficiency in the maternal diet also affects the fœtus, in that numerous hæmorrhages develop in various parts of the body and limbs and can cause considerable destruction.

It is rather natural that the effect of fluorides on fœtuses should have been studied, but the fact that radio-active fluorine ^{18}F has such a short half-life (112 min.) would mean that investigations using it as a tracer would have to be conducted virtually alongside the pile. Fleming and Greenfield (1954) have found that more than 600–700 μg. of CaF_2 and 1000–1200 μg. of NaF produced resorption of fœtuses or caused stillbirths in rats. Lower dose levels administered during pregnancy resulted in retardation of calcification of the jaws of the neonatal rats. There were also changes in the ameloblasts, retardation of maturation of the enamel matrix, and hyperæmia of the vessels in the pulp with breakdown of the endothelium.

The placental transfer of ^{45}Ca, as studied by Feaster, Hansard, Outler, and Davis (1956) in the rat, shows an increase of nett transfer by a factor of 32 between the fourteenth and twenty-second day of pregnancy. Their work is also of interest in that it indicates that a portion of the calcium that traverses the placenta and is retained in the fœtal bones and teeth must be calcium that had previously been stored in the maternal tissues. Radioactive calcium has been injected into dogs by Eichler, Appel, and Ritter (1955), and its subsequent distribution in the tooth germs was indicated by a specific activity in the outer layer of dentine greater than that of the plasma; the activity of the enamel was equal to that of the plasma. Such methods of study are only in their infancy, and when correlated with the increasing knowledge of fine structure that is, and will be, the outcome of electron microscopy of hard tissues we may well learn about the mechanism of tooth development at an anatomical level that has so far been denied to us.

Incidentally it has frequently been maintained, the evidence being provided from the results of experiments with radio-active isotopes, that the placental transfer rate of certain substances increases steadily during pregnancy. It is said to increase so greatly that the fœtus is provided with an abundance above its needs, and the expression "safety factor" has been used by Flexner to denote this excess. A word of warning is, however, needed here, for many substances traverse the placental barrier with equal facility in the opposite direction and we are therefore dealing with a series of fluxes to and fro across several membranes. We are only now starting to learn a little about the placenta's own activities as an organ in its own right, its ability to synthesize, to transfer against the gradient, to store substances, and to act as an endocrine organ. It is quite clear that it is more complicated in structure and function than a simple semi-permeable membrane, and I am sure it is obvious from the brief remarks that I have made that as a barrier the placental membrane leaves much to be desired.

INFECTIOUS DISEASES

It will probably be well known to you that gravidic rubella can be teratogenic at certain stages of pregnancy in man (Gregg, 1941; Swan, 1948). The main injuries to the fœtus involve the eye and the heart, but there has been some controversy as to whether there is an effect on the teeth.

Raison, Lepoivre, and Chatillon (1954) have examined 15 children whose mothers developed rubella early in pregnancy, but the few minor

abnormalities they found could not be attributed with certainty to the disease. Unfortunately no animals have been shown to be susceptible to rubella, so experimental work is not possible.

Experiments have been performed with Newcastle disease virus, vaccinia virus, and with *Rickettsia prowazeki*. Vaccinia virus causes striking gross and microscopical defects in developing teeth in rabbits but dental defects are difficult or impossible to detect in fœtal tissue. Newcastle virus introduced into chick embryos a few days old causes cytoplasmic degeneration and defects in the neural tube, lens, and eye vesicles. The virus of influenza A can also produce widespread embryonic deformities (Hamburger and Habel, 1947).

Giroud has commented on the possibility of teratogenic effects due to the pyrexia (*see also* Kreshover and Clough, 1953) associated with many infections. Evidence has been produced that rearing of larvæ and eggs of *Rana berlandieri* and *Bufo cognatus* (Bresler, 1954) may result in abnormalities of labial teeth and variations in their "developmental hardiness". At least these experiments indicate the need for caution in using such structures for taxonomic purposes.

RADIATION OF EMBRYOS

Even within the limited literature on this subject a large variety of abnormalities have been reported as resulting from irradiating mammalian embryos (Russell and Russell, 1954). Irradiation with 200 r during the period covering day $6\frac{1}{2}$ to day $12\frac{1}{2}$ of pregnancy in mice produces the highest incidence of abnormalities. It is perhaps of greatest interest to the present discussion that certain abnormalities, such as cleft palate, can be produced by exposure to irradiation at two particular periods, day 8–9 and day 10–14, of pregnancy in the mouse. Mice fœtuses irradiated with a single exposure of 300 r at day $15\frac{1}{2}$ of pregnancy were born with bones having dimensions smaller than normal (Levy, Rugh, Lunin, Chilton, and Moss, 1953); children with significantly smaller height, and head circumference, were born to mothers with "major" signs of radiation after the atomic bomb blast in Nagasaki. In view of the increasing importance of the possible deleterious effects of radiation during pregnancy I should have liked to have considered this subject more deeply, but perhaps I had better leave it to someone having more expert knowledge.

EMBRYOLOGICAL CONSIDERATIONS

It should be clear to you that the factors that so adversely affect the development of the embryo do so at a particular time in its life, or if I may use the technical embryological term, during specific horizons. We owe the transference of this term from geology to embryology to the late Dr. G. L. Streeter, of the Carnegie Institute of Embryology. He implies that it is not so much the precise age of the embryo that we must know, but that it is the successive stages of development of a particular tissue or organ and its interrelation with other embryonic events that are important. Streeter described and evaluated before his death the various events for some eight horizons in early human development, and this approach has been widened by more recent workers. Streeter's concept has become extremely relevant, and, as the results of the experimental work become clearer, the more urgent it is that we should possess a lucid plan of the events during each horizon in the development of jaws and teeth. It will be apparent from some of the work that I have quoted that certain important embryological events, such as the closure of the secondary palate, in fact occupy merely a matter of hours, being both a period of time and an event that will have vital significance in the subsequent form of embryonic development. We should not, however, remain at a purely morphological level, and it seems to me that the particular situation that covers the development of teeth and jaws has been crying out for histochemical and other investigations within an overall pattern covering events in the region of the mouth. Some preliminary investigations have been reported by Bevelander and Johnson (1949, 1955) and by Symons (1955, 1956), but they have been principally concerned with distribution and localization and not with the succession

of histochemical horizons from tooth germ to tooth germ. Ten Cate (unpublished) has been engaged at the London Hospital Medical College in making a collection of human tooth germs suitably fixed for investigating such matters. He finds, notably, that histochemical findings may be correlated with horizons of development in the dentition. For instance, the enzyme alkaline phosphatase shows a gradient of distribution in the enamel organ, reflecting the stage of development attained.

The presence of alkaline phosphatase in the enamel organ has for long been associated with calcification. However, the finding that this enzyme appears in the external enamel epithelium cells coincidently with the appearance of blood-vessels along its outer surface, and that prior to this, when the external enamel epithelium is phosphatase free, there exists below it a layer of undifferentiated stellate reticulum cells, rich in alkaline phosphatase, suggests a metabolic function for the enzyme, that of membrane transfer. Thus any factor causing a disturbance of phosphatase function can be expected to produce, not only anomalies of calcification, but also far more widespread effects of nutritional disturbance.

The pattern of glycogen distribution also reflects the phases of dental development, the most striking example being the complete disappearance of this polysaccharide from the stratum intermedium and the ameloblasts with the onset of the calcification of pre-dentine. A disturbance of glycogen function may thus express itself not only in ameloblastic dysfunction, but also perhaps in dentine formation.

From these, and other findings, it is suggested that, if any factor is found which affects specifically the histochemical pattern of development, its effect on the developing dentition may be forecast, dependent upon which histochemical horizon any tooth germ lies in at that particular moment.

Several Northcroft lecturers in the past have reflected on the potential importance of the work of Shirley Glasstone (1936, 1938, 1952, 1954) and of Szabo (1954) on culturing tooth germs. This pioneer work would seem to me to have even greater potentiality if it were possible to examine the effects of some of the substances I have mentioned when added to the culture medium, or if the tooth germs were removed from fœtuses whose mothers had been treated in the various ways indicated.

CONCLUSIONS

W. Landauer (1954) has, I think, summed up matters thus: (1) "Modifications of development with morphologically similar end effects can be produced by chemically specific interference at different points along one and the same pathway of metabolic functions." (2) "The occurrence of syndromes of malformations involving several independent parts and organs of the embryo finds its explanation in relatedness of metabolic requirements during particular sensitive stages of development." (3) "The developmental defects, presumably those of genetic as well as those of experimental origin, are brought about by an intervention in metabolic events on the cellular level."

The experimental work that has just been briefly reviewed would seem to me to be of threefold value. It is a warning to anatomists, anthropologists, and all concerned with taxonomy—that is to say those who classify, such as orthodontists—in that they should not argue too strictly from phylogeny, but must always remember the modifications that can occur during ontogeny. It is a warning to all who seek an explanation for dental disease in dietary deficiencies or excesses in the adult, and for those who maintain that jaw form is the result purely of mechanical or muscular forces. All such factors undoubtedly operate, but to my mind far too little attention has been paid to those factors that ordain and influence during embryonic life the *quality* of the tissues and structures on which one works later in ontogeny. My third point is that it would seem that the field of research that I have reviewed is one in which clinical–preclinical co-operation can hardly fail to increase our knowledge on these interesting and important matters. It would seem to me to be virtually negligence if, in the future expansion of dental studies, one does not spare some space, time, and personnel to investigate this field of research.

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DISCUSSION

Professor Miles (London Hospital Dental School) said he happened to know that Professor Harrison had been a little hesitant about presenting these matters to the meeting for fear they would not arouse the interest of the practising orthodontist, but undoubtedly the applause with which his address had been received would have reassured him on that score. Orthodontists would be grateful to him for using the opportunity of the Northcroft Memorial Lecture to bring to their attention a great deal of work which had not perhaps made the impact upon the field of orthodontics that it deserved. Professor Harrison's lecture would provide them with much food for thought and perhaps for flights of speculation.

Referring to the series of rats with short mandibles, Professor Miles said it was impossible to avoid drawing a comparison between that condition and the inferior retrusion which was such a source of trouble—and presumably also income—to orthodontists. It was astonishing and somewhat disquieting to realize that these abnormalities resulted from deficiencies of riboflavin far too small to produce any symptoms in the mother.

He had been very interested to discover that Hale's work in 1935, to which Professor Harrison had referred, on eye defects, cleft palates, and hare-lips in pigs on vitamin-A deficient diets did make a very profound impression on at least one dentist, Weston Price, who, in his book *Nutrition and Physical Degeneration* (1939), devoted a whole chapter to what he called "pre-natal nutritional deformities".

Professor Harrison had hinted at a possible pathway, via cortisone or adrenaline production, whereby emotional disturbances in the mother, or even in the fœtus, might upset development. Professor Miles said he would leave it to others interested in behaviour patterns to comment on the possible significance of the resentment which the fœtus appeared to have for the music of the washing machine, but it did recall the view held by our forefathers, who believed that development could be disturbed in a specific way by maternal emotional disturbances; thus the deformed leg of an infant might be attributed to the mother having been frightened by a one-legged man.

In connexion with Professor Harrison's account of the development of the face it would be interesting to have his opinion as to whether the occasional occurrence of a narrow strand of tissue across a cleft, of which two examples could be seen in the slide (*slide shown*), was in accord with the view that the grooves between the embryonic processes were smoothed out by the sort of flow of mesoderm which Professor Harrison had described. According to some workers, when a cleft was formed there was first of all union, at least of epithelium, followed by secondary breakdown which separated the processes again.

He wondered whether Professor Harrison would care to say anything about Rhesus factor incompatibility as a cause of disorders in development. There was a type of enamel hypoplasia which was attributable to Rhesus factor incompatibility, although he believed it was regarded as being secondary to the jaundice usually present in the infant.

Professor Harrison had made a plea for more research into these matters, and it was in fact a field in which the clinician could make a very considerable contribution. It was now twelve years since attention had first been drawn to the high prevalence of enamel hypoplasia in infants born of mothers who had rubella during the first few months of pregnancy, and yet there was still lacking a detailed description of the type of hypoplasia that was present, so that even the discovery of a single authentic case—a chance which might come to any practitioner dealing with children—could advance knowledge very usefully. It was, after all, the acute observation of a clinical ophthalmologist, Gregg, in Australia, which first brought to light the rubella story when he noticed the association between the sharp increase in the number of congenital cataracts he was seeing and an epidemic of rubella a few years previously.

Mr. Glass, referring to the cortisone or ACTH method of producing clefts, said he understood the author to say that it produced isolated cleft palate, and not complete clefts of lip and palate, whereas it appeared from work done by Fairbairn that there was no differentiation between cleft palate and cleft lip and palate. If there was a differentiation how did Professor Harrison account for the fact that in Fogh Anderson's published work on human beings the females had cleft palate twice as often as the males, whereas the males had complete cleft lip and palate twice as often as the females, and how did he fit that in with the rats producing only cleft palates when administered with cortisone?

Another point was that clefts of lip or palate had been produced quite a considerable time after the embryological union of the various tissues of the face, so that although Professor Harrison suggested that it occurred only at the union date, Fairbairn had produced the cleft quite a considerable time afterwards, thus suggesting that the cleft was not necessarily due to a breakdown in the union but may have occurred long after the union had taken place. This supported Professor Miles' slide of the epithelial tissue bridges across a cleft, which was not uncommon.

An interesting point was that if the palate closed in a matter of a few hours like two trap-doors coming together, where did the elastic tissue come from? It had been suggested how they closed, but could Professor Harrison say why they did not close when the cortisone was given?

Presumably with the various dyes, it was possible to produce any given malformation, and it would be interesting to know whether the speaker had been able to produce any cranial defects in rats experimentally.

Mr. Ballard said he felt very diffident about speaking because he feared that he might "put his foot in it" if he attempted to ask a question!

First, he wished to ask whether Professor Harrison could state more definitely at what time those chemical substances acted in the uterus. He had given the impression that they appeared to act at any time in utero-development, but on the other hand it would appear that most of the abnormalities about which he was speaking were the result of chemical substances preventing the formation of the more primitive tissues, and that possibly, therefore, the abnormalities that were produced were the grosser abnormalities and not the things which orthodontists were dealing with and which nowadays they were tending to call not abnormalities but variations. The gross abnormalities were the rather extreme things about which Mr. Greer Walker had spoken on previous occasions.

With regard to riboflavin deficiencies and underdevelopment of the mandible, if such abnormalities were to be regarded as being due to minute deficiencies of riboflavin in the pregnant mother how did Professor Harrison account for the fact that in certain of our racial groups where the mandibular underdevelopment was quite common there was also in that same racial group a very common degree of the opposite condition? In other words where those variations occurred they were extremes either way.

Mr. E. Broadway asked whether there was any evidence to show that pregnant women living under stress in wartime produced more congenital abnormalities in their babies than were produced now under more normal conditions.

Mr. Plint said Professor Harrison had drawn largely on animal experiments for his subject-matter, but in the past a large amount of experimental dental work had

been done on animals and subsequently was found not to be true. There had been a good deal of work on dogs which not many people accepted to-day, and also in a large number of experiments on the incisor teeth of rats it had been found that there was no direct parallel, and perhaps Professor Harrison could say what sort of parallel he was drawing.

He personally had seen a large number of Bantu in South Africa on an extremely low diet, and during the eighteen months that he had worked amongst the children he had never seen any cleft-palate cases, and very little hypoplasia of their teeth.

Mr. Greer Walker said many people present would have liked to have had Professor Harrison's paper to peruse for an hour or two before coming to the meeting, and those who had to deal with human beings would realize that there were slight differences which it was very difficult to get over.

He was particularly interested in facial clefts, and if one omitted the odd clefts, about which there might be a great deal of discussion, and confined one's attention to the *auro-tregal*, those who had been born, bred, and reared on the embryological processes had always looked upon that as one in which there was the maxillary and mandibular process failure. That was probably the most common facial cleft which one saw, and it would be interesting to know Professor Harrison's explanation of it.

Mr. W. Finkel asked whether there was any known association between the overdosage of vitamins and deformity.

The President, referring to Professor Harrison's entirely new conception regarding the closing of the clefts during development, asked whether that implied that in the clefts which were left open as a result of lack of mesoderm there was a deficiency of substance in the clefts.

Referring to the author's remarks about levels of vitamins producing death, deformity, normal development, and then deformity again, would it be possible for him to give some idea of the levels relative to normal dietary intake which produced those varying degrees of development?

There was another question which Professor Harrison had not touched on at all and which even Mr. Ballard had managed to keep off, and that was the question of uterine environment in the possible development of abnormal behaviour. He personally felt there was quite a possibility that such environmental factors might be provocative of those abnormal behaviours. As Mr. Ballard had said, orthodontists deal with variations in the occlusion of the teeth and not true abnormalities.

Professor Harrison, replying to the discussion, said he wished to make it quite clear that when he was so kindly asked to give the lecture, he had wanted to put before them certain views on the development of the face and on causation of abnormalities that were perhaps a little different from those generally accepted. Many of the experimental findings could not yet be explained, but certain points could be made.

For the first time in the history of embryology there were some definite facts known about the causation of abnormalities, and of variations, which enabled one to go into the laboratory to-morrow and, with animals in the appropriate stage of pregnancy, certain experiments could be done and a number of abnormalities would be obtained. This had only recently been discovered and he believed it to be of great significance, whether it be in rats or any other animals. Whether or not the results could be obtained in man would only be determined when the genetic constitution of man could be compared with that of animals. That probably was really the answer to many of the questions.

A certain genetic pattern should express itself in the production of a genotype, but developmental processes could be exposed to successive types of interference right from the time the oöcyte existed in the ovary. In the case of muscle behaviour in embryos, for example, in maternal vitamin-E deficiency there followed disturbance in development of muscle function in the fœtus. He was not suggesting that seeing rabbits or one-legged men caused abnormalities; on the contrary he had tried to show that certain abnormalities could be caused by deficiencies of certain vitamins in the maternal diet.

As to the degree of deficiency, if the amount of riboflavin in the diet was decreased to more than 20 per cent below that of the normal everyday requirement for a pregnant rat there were many abortions and deaths among embryos. As the amount of riboflavin neared that required for production of a normal fœtus there were fewer deaths, but more abnormalities. It was difficult to tell the deficiency for every substance because it was difficult to assess the actual level in the diet of some teratogenic substances.

With regard to closure of the palate, in a mouse of about thirteen and a half days one could flick the palatal process up and down and it would stay up or down; the processes were either right down with the tongue intervening, or right up. A few days earlier the palatal process was down and it would not flick up. One could push it up with a pair of forceps, but it would not flick. The stage when it flicked came on suddenly and had been associated by Fraser and Walker with development of a particular type of elastic connective tissue. Many other suggestions had been made to account for failure of fusion; the degree of œdema, which was difficult to assess in an embryo; the degree of vascularization, which might be concerned in the cases where the palate had apparently united and then broken down. Where there was edge-to-edge fusion inadequate vascularization was difficult to prove scientifically.

There was quite definite evidence that overdoses of vitamin A produced similar abnormalities to those that followed deficiency of that vitamin, and they constituted a veritable "text-book of abnormalities".

Referring to facial clefts, mesodermal territories were well shown by distribution of nerves of the face, and it had been suggested that there was a correlation between embryological activity and the way in which nerves migrated. Each nerve started centrally and migrated peripherally; something must guide them. It was known that there was a relationship between nervous and mesodermal development. Many abnormalities of the nervous system were associated with those of mesodermal derivatives.

With regard to the maxillary and mandibular processes, embryologically both are part of the first arch. The maxillary process started as an outgrowth from the first arch, clefts between the two were not difficult to explain; there were others that were not so simple.

With regard to observations on different racial groups, as in the case of different strains of animals, were they not all genetically different? The Esquimaux and the Bantu exhibited differences in structure, presumably genetically determined; might there not be differences in texture and behaviour, say in the enamel, that were

not so apparent? The problem was how did the environment affect each particular genotype? The validity of arguing from animals to man was to be the subject of the Huxley Memorial Lecture at the Royal Anthropological Institute later that month by Professor J. B. S. Haldane, who would be much better qualified to answer that question.

Mr. Glass had raised the matter of sex difference, but there was little experimental evidence on that in animals. In his paper he had avoided discussing the effects of sex hormones; their effects on embryos were often paradoxical. Little evidence was available on the effect of stress during pregnancy in wartime; the stress of being taken prisoner often suppressed menstruation, and low diet was associated with infertility.

Of cranial defects caused by trypan blue there had been many examples of anencephaly. Giroud had produced interesting results in showing the formation of extra brain tissue, ectopic ganglionic masses, where no nervous tissue should be, in association with deformities of the skull.

How the palate in fact closed and whether epithelium between the two palatal processes broke down and how it was invaded by mesoderm could perhaps be better understood with the help of the electron miscroscope or histochemical techniques. It would be well worth examining just how cortisone and other substances interfered with the mechanism and what the effect of cortisone was on the elastic fibres or mesodermal cells of the palatal process.

An attempt had been made to collect information about any association between cleft lip and cleft palate, but experimentally it appeared that hare-lip was unrelated to cleft palate. One might suspect that there was a difference in timing between the two mechanisms. A whole series of events was emphasized much earlier in the facial region; the palatal processes were only minute ridges when facial development was going strongly. He thought, however, that experimental work on this question should quite clearly be taken as a series of scientific observations on the one side, with observations on human cases on the other, but as more was found out so it might be possible to bring the two aspects closer together.

With regard to the Rh factor, he had not yet seen any abnormalities in jaws or teeth ascribable to it. He was, however, much interested in work that had suggested that tissue destruction during placental development could result in a transfer of maternal substances, perhaps antigenic, to the fœtus, and more important vice versa. The Rh effect occurred over a prolonged period and at a time not associated with palatal closure.

As to bridges across clefts, he had been all along explaining Streeter's views on facial development; it might be that the mesodermal growth centres pushed out mesodermal cells to iron out clefts, but that the mechanism was inefficient. When one saw a little strand of tissue across a cleft what had happened was uneven activity in the growth centres. Growth had proceeded locally and then stopped, locally somewhere else and stopped. Preliminary activity was such that a bit of epithelium was rounded off as a strong point left behind. Failure of other closing mechanisms such as elastic properties in the palate resulted in a final structure that had been unable to complete its developmental programme. That was only a suggestion, he just did not know the correct answer.

A vote of thanks to Professor Harrison, proposed by the President, was carried by acclamation, and the meeting then terminated.

REPORT ON A VISIT TO THE UNITED STATES AND CANADA

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THROUGH the generosity of the Newland Pedley Trustees I was able to make a three-month visit to twelve Dental Schools in the United States and Canada during the spring of 1956. There were important centres in this vast continent which I was unable to visit in the time, but I was present at the Annual Meeting of the American Association of Orthodontists in Boston attended by nearly 1200 delegates. Therefore I was able to meet many of the men whom I had not had the opportunity of seeing in their home schools.

Following Pringle's example I propose to divide this report into Orthodontic Teaching, Research, and Clinical Practice.

TEACHING

Previous visitors to the U.S.A. have reported that although the undergraduate dental students usually attend a full course of lectures and possibly a technique course, nowhere did they have the opportunity of carrying out active orthodontic treatment in the same way as in some schools in this country. The position has changed somewhat in the last few years.

At the University of Illinois in Chicago, where I spent the first three weeks, the influence of Edward H. Angle is probably the strongest. This was the first school to establish a graduate course leading to a degree. The undergraduate students have a very comprehensive series of lectures, but they do no clinical work on patients. The accent is on the Graduate course, which consists of six consecutive quarters of full-time work including intensive seminars in the basic sciences. The fixed appliance therapy taught here is confined almost exclusively to the edgewise technique; very few cases are treated by extraction. Dr. Brodie believes that if one method is taught thoroughly the student is best equipped to tackle any type of malocclusion. The headcap or cervical strap used with a fixed upper bow and bite plate is used in the early cases of Class II division 1 malocclusions and is referred to as "guiding treatment", usually followed where necessary by full treatment.

At the Northwestern University, under Dr. Thompson, the undergraduates do little clinical work, but they have lectures and tutorials from Dr. Thompson, Dr. Graber, and the instructors. There is a strong accent on the anatomy and physiology of the temporo-mandibular joint. Here again, the graduate side receives the main emphasis and the edgewise, twin-wire, and labio-lingual techniques are taught.

In Ann Arbor at the Dental School of the University of Michigan there is an active Undergraduate teaching programme. The undergraduates spend a certain proportion of their time in the Orthodontic Clinic and handle a large number of cases. Like all of us who attempt this, they are having their problems. They have a large graduate programme requiring partial duplication of staff. The problem is to find suitable cases for undergraduates to treat and complete. All post-graduates prefer not to work on partially finished cases. This undergraduate programme means that fairly extensive use is made of removable appliances, reflecting the influence of Harvold when he was there.

In Toronto there is also a part-time undergraduate orthodontic programme. This is limited to relatively simple procedures, but provides the student with the basis of general practitioner orthodontics. In the graduate school a full range of fixed-appliance techniques is taught by different members of the staff on a part-time basis.

In Montreal I visited the French-speaking University and found a most enthusiastic group of graduate students under the direction of Professor Geoffrion, who attends part-time

Given at the meeting held on December 10, 1956.

at the School. The twin-wire was the fixed appliance receiving the main emphasis and Professor Geoffrion has just published a book on this subject. Many removable appliances are used incorporating the modified Arrowhead Clasp.

The Department has fine physical facilities. I noticed that there was a very high standard of photography. In this school the undergraduates have lectures and are taught simple preventive measures and treatment of the less difficult cases. A novel point about this school is that drawing and painting are stressed during pre-clinical studies and each student has to show a real proficiency in this before proceeding to clinical work.

I was unable to assess the teaching at McGill, the English-speaking University, as they were just taking over new premises.

At Boston, the Harvard School of Dental Medicine, there was no full-time graduate programme but a very active Undergraduate programme on a part-time basis. I sat in on a seminar on a Saturday morning where undergraduate students were presenting cases and was most impressed with their grasp of the subject. They extend this part-time course over their clinical period.

At Tufts, under Professor Margolis, the accent is mostly on graduate teaching and here the appliance therapy is mainly edgewise, using the Tweed technique. The undergraduates have an opportunity for a limited amount of clinical experience apart from a full course of lectures.

The Forsyth Dental Infirmary for Children is of course not an undergraduate teaching school nor is it a Graduate School in the strictest sense. Appointments here, however, give the Fellows opportunities for clinical work under the direction of Dr. Moorrees and I found a variety of appliances being used, including many removable.

Therefore, I believe that there is a definite increase in undergraduate teaching and in some schools this approaches or passes the undergraduate facilities in this country. Basically, however, the graduate programmes dominate the picture and enable a thorough training to be available to a large number of students. Many of these students work for a Master's degree by thesis in addition to the diploma for the completion of the course.

Most schools provide a part-time course for postgraduates, with the aim of keeping them abreast of current views and appliance techniques. Some of these courses are designed for the general practitioner. The University of Illinois has taken the telephone course to its logical conclusion by providing a closed-circuit television course in various subjects, of which one is Orthodontics. This can be relayed on closed circuit to five cities as far apart as Minneapolis and Indianapolis. Practitioners at each University centre are able to see close-up practical demonstrations.

RESEARCH

I was privileged to attend the Alumni meeting of the graduates of the University of Illinois during my first four days in Chicago. This meeting was attended by a large number of the Alumni, including the heads of five departments of teaching schools in the States. Professor Wilton Krogman and Dr. Holly Broadbent were present as Honorary Members. At this meeting, apart from many interesting papers from senior men, I heard summaries of the theses presented for the M.S. degree since 1951.

One must remember in reading the publications of these theses that the material is often limited and the objective a small one. It is an excellent idea for graduate students to undertake projects of this kind. Unfortunately, however, few of them will go on to teaching appointments where their research abilities can be continued. I think we should read with caution some of their findings in the early stages of this work.

Dr. Thurow gave a most erudite paper on cephalometrics at this meeting, in which he made this very point. He criticized the methods of superimposition of serial X rays and the small amount of material statistically analysed.

Despite the criticisms that have been made concerning the use of the cephalometer in diagnosis it must be agreed that it is an excellent research tool in longitudinal growth

studies and I was privileged to spend two weeks with Dr. Holly Broadbent in the Bolton Foundation, where I was instructed in the use of the Bolton cephalometer which Charles Bolton has munificently donated to Guy's. Dr. Broadbent spent a considerable amount of time with me and I was permitted to select material from the unique files of the Bolton Study for a small research project.

This was in connexion with patterns of facial growth in Class II cases. With the limited time at my disposal I was able to trace a series of untreated Class II division 1 cases, and I was particularly interested to observe changes in axial inclinations of the incisor teeth as they erupt. This material will form a paper in itself.

One thing that is emerging from all cephalometric studies, particularly in relation to Class II cases, is the phrase "growth potential". Brodie still holds the view that the pattern of growth of the basal elements of the jaws is not influenced by orthodontic treatment, but he points out that it is the growth potential which we find difficult to assess. Where we get a considerable improvement in our Class II cases, it is the growth potential of that individual which is probably the major factor. There has been much too literal an interpretation of the statement that the skeletal pattern cannot change.

I think cephalometric research will in time settle down to a number of long-term studies which will continue to yield valuable material with the steadying influence of more senior men and the criticism that is being offered.

Under cephalometrics I should include laminagraphy and the excellent work that Ricketts and others have done. Special mention should be made of this work in connexion with the temporo-mandibular joint and in analysing paths of closure in Class II cases before and after treatment.

At the end of the Alumni meeting in Chicago, Brodie forecast that the research tool that would come to the fore in the next few years was the electromyograph. There is no doubt that there is an ever-increasing interest in the relationship between the soft-tissue activities and malocclusions. There are many investigators who are using the electromyograph in research projects and I made it my particular business to meet most of them. In Chicago, at the University of Illinois, Pruzansky and some of the graduate students are doing very interesting work; Perry and others at the Northwestern; and Jarabak at Loyola. Moyers, who was the first to use it as a dental research tool, is continuing his work at Ann Arbor.

There is a particularly active series of investigators at the University of Toronto Dental School and I was able to discuss problems with Dr. Basmajian in the Anatomy Department, who has spent some time with Bauwens in this country.

Most of this aspect of orthodontic research is directed to muscles of mastication and the postural muscles of the head and neck, and we can look forward to many publications in the future.

In assessing the importance of this work one is conscious that many investigators are not entirely satisfied with their techniques. I had lengthy discussions concerning the type of equipment, electrodes, the placing of electrodes, and particularly the interpretation of the results. I do not propose to say much on this subject, but I had some discussion with Dr. Sicher, who speaks his mind quite forcibly and points out that without clinical interpretation all that the electromyograph shows is that a muscle is contracting. It does not interpret its action. It may be a prime mover or an antagonist.

I still think that workers in this field have a long way to go. Moyers claims more for this apparatus than others. Pruzansky I found cautious and critical of technique. He has hesitated so far to publish more than a general paper on the applications of this to orthodontic research. I would criticize the placing of a so-called reference electrode over the sixth vertebræ or the ear and one on the muscle to be examined. In the case of the post-temporal, if you ask the patient to give a most retrusive bite, you get contraction of not only the posterior fibres of the temporalis but also of the post-cervical muscles. If you place your hand on the back of your neck and make a forced retrusive bite you can feel this happening.

This point was made to me by Pruzansky and Peary.

An unpublished thesis by Boyko in Toronto makes an exhaustive appraisal of different electrode positions in studying the temporalis muscle. He has shown that the posterior fibres may be just as active in closing movements in some Class I cases as in some Class II, division 1 cases by using different techniques. This is in addition to those Class II cases that have a forward posture at rest and therefore naturally show excessive contraction of posterior temporalis on closure.

With regard to the circumoral musculature, Karau and others, in theses presented at the Northwestern University, have made a study of normal and abnormal circumoral forces. Unfortunately like most of these graduate theses, the time and material have been limited but the ideas are worth following. Most of the instruments used for electromyographic analysis were adapted electro-encephalograms with crystographic recording apparatus. The most satisfactory equipment I found was used in the Anatomy Department at Toronto. This was an English product, incorporating six channels with oscillographic recording.

There are a number of workers using strain gauges and other methods of measuring intra-oral pressures. Last year Dr. Anderson reviewed the work on masticatory forces, but one piece of work that has received special attention this year is the prize-winning essay of the American Association of Orthodontists by Winders, recently published in full in the *American Journal of Orthodontics*. This is a very neat piece of research work and I only hope that despite his entering practice he will have the opportunity to continue. His preliminary findings would seem to some people not to tie up with our views on muscular behaviour, implying that his results agree with Sicher's views that the peri-oral and lingual musculature does not exert much influence on the positioning of the teeth. In his summary Winders says that "the results of this investigation indicate that there is an apparent imbalance of muscular forces acting on the dentition between the lingual and the buccal sides, with the greater force being exerted by the tongue".

I have spoken to him personally and he is the first to admit the limitations of his experiments to date. They were conducted on seven cases having ideal occlusions. I suspect that he will discover, as we are now finding, that it is the absence or presence of positive tongue pressures which is the important factor in moulding the incisor segments of the dental arches, and when a large series of cases is investigated by his method, although there may not be any measurable pressures from the cheeks, there certainly are cases which indicate excessive contraction of the lips. In the last paragraph of his paper Winders says: "to appraise definitely the effect that muscular forces have on the dentition, and the degree of this effect, would be a problem which could be clarified only through extensive, well-co-ordinated investigations".

I was privileged, through the kind introduction of Dr. Salzmann, to read a paper at the Association's Annual Meeting and I attempted to distinguish between what the Americans describe as muscle habits and the more basic atypical behaviour. There is still a tendency to overemphasize the value of muscle exercises in treatment.

Interest was shown in the work of Rix, Gwynne-Evans, Ballard, and others in this country who have been studying these problems. I quoted Angle's statement in the seventh edition of his book (1907). This is what he said: "We are just beginning to realize how common and varied are the vicious habits of the lips and tongue, how powerful and persistent they are in causing and maintaining malocclusion, how difficult they are to overcome.

"The period of retention of the teeth after they have been moved into normal occlusion is one of the most important in treatment and so complicated and persistent are the delicate forces that tend to derangement of the established occlusion as to necessitate the most thoughtful consideration of the problems involved and a degree of skill in overcoming them which much experience alone can develop, even among those with talent for the work." I pointed out that Angle would not face up to the immutability of soft tissues in some cases.

I found particular interest shown by Professor Bloomer, Professor of Speech Therapy in the University of Ann Arbor, in our problems of oromuscular behaviour. He was cognizant of all the work that had been published in this country and had come to similar conclusions regarding the underlying abnormalities associated with tongue/lip posture. I was able to show his student Speech Therapists the film which Gwynne-Evans and I showed before the Society last year.

At the Boston meeting Dr. Herbert Cooper showed a most interesting ciné-fluorographic film using image intensification, just published in the *American Journal of Orthodontics*. This was particularly used in relation to cleft-palate cases, but there is no doubt that there is a future in this for the study of soft-tissue behaviour although there are a number of technical difficulties.

I had the good fortune to meet Dr. Sillman, who was reading a paper at the American Association of Orthodontists' meeting. I was able to see the continuation of the series of models that were shown over here by film nine years ago. Serial studies are also proceeding with models in the Institute of Human Biology at the University of Michigan and some of the graduate students here are examining this material.

Tucked away in the small town of Burlington, 60 miles from Toronto, I found a most interesting research unit attached to the University of Toronto Dental School under the direction of Frank Popovitch. This was initiated by Moyers while he was in Toronto.

In this investigation 300 children are being treated by simple methods using removable appliances. A so-called control group of more than 1000 children are being kept under observation with serial models and lateral skull radiographs. Initially they tried to use the electromyograph, but its use as a routine investigation has been discontinued. A short write-up of this can be found in the *Canadian Dental Journal* and I am sure we will hear more from this study in due course. Apart from the Director, there is a geneticist, three orthodontists, two pedodontists, a secretary, and two technicians on a part-time basis.

At the Forsyth Dental Infirmary material has already been published by Moorrees from the Stuart Study incorporating skeletal maturation and dental development, and there is considerably more material available here. There is also a vast series of models of untreated children in Honolulu which were supplied by Dr. Hoey. Unfortunately, the registration of the bite in some cases is difficult; otherwise this would have provided an excellent study of natural improvement or deterioration over a long period of time.

This section on Research would not be complete without mentioning the many centres where the cleft-palate problem is being enthusiastically tackled. At the Illinois school, Pruzansky has an infant cephalometer and at the Northwestern they are just installing a special high-voltage X-ray equipment capable of an exposure of a fiftieth of a second for infant skull X rays.

CLINICAL PRACTICE

In discussing clinical practice it is unnecessary for me to say that multi-band techniques form a greater part of the armamentarium and treatment tends to be started in teenagers. It was not possible in the time available to study one technique in great detail and you will be hearing details of the latest edgewise methods from Halden in February, 1957.

I was privileged to spend some time with a number of leading orthodontists in their offices and one could never fail to be impressed by the speed with which whole mouths are "strapped up". I did notice, however, that considerable use is made of round wire before final adjustment is made with true edgewise arch. Twin brackets had been produced which some people are using instead of the single bracket and two staples in effecting rotation.

Apart from multi-band techniques there is a tendency to use the headcap with Hawley bite plate as an early approach to the treatment of Class II, division 1 cases.

The return to the use of cervical and occipital traction is received with mixed views in various parts of the States. Despite

criticism of the problems of anchorage in the lower arch with intermaxillary traction, the labio-lingual technique is still used by many orthodontists and I was privileged to spend some time in private offices in Boston where it is used exclusively. Here I saw models of the original case first treated by Dr. Lawrence Baker with intermaxillary elastics.

Cephalometric analysis still plays a prominent part in diagnosis, particularly for the younger man who is taught one of the rather empirical methods of case analysis according to his particular school. However, many of the older men do not use it as a diagnostic tool in the same rigid way. Dr. Holly Broadbent is a firm believer in assessing growth potential by examining a series of pictures, both lateral and frontal, taken at intervals before active treatment is commenced.

The purely mechanistic approach is losing its intensity and the problems of soft-tissue interference are being noticed more and more. I have pointed out that research is tending towards investigation of soft-tissue behaviour.

There is still controversy between the extractionists and the non-extractionists. One could not fail to be impressed by the results obtained with the edgewise arch in some of these non-extraction cases and their stability.

Serial extraction techniques are becoming more popular and two papers were read on this subject during my time in the States. Where appliance therapy is required it is, however, usually continued with partial use of the multi-band technique. Dr. Dewel of Evanston gave a paper on this subject at the E.O.S. meeting in Stockholm.

While attending the Boston meeting of the A.A.O. one could not help commenting on the display of equipment by the various companies. So many things are pre-formed that the multi-band technique is not as time-consuming as it is in this country.

There is certainly an increase in the use of removable appliances. I mentioned this in discussing the teaching, but I am certain that they will never be used as universally as in this country unless a large Public Health scheme comes into operation. Another definite trend I feel is towards more treatment in the mixed dentition and this is advocated by many leading authorities.

The Hawley bite-plate is being constructed by many people in their offices without technicians using the quick-curing technique. I have seen these made up between patients. They seem to stand up quite well to wear and there does not appear to be any reaction of the mucosa to free monomer. A removable appliance may be used in conjunction with molar bands in cases of Class II traction to attempt to stabilize the anchorage in the lower arch by closely applying the acrylic to all the teeth.

Additions of palatal springs to removable appliances were shown in the postgraduate courses given at the University of Illinois, and wherever there is a definite European influence one sees occasional use of the activator in the office. The positioner, which is made of rubber, is also being used not only as a retainer but for some active tooth movements.

As I mentioned in discussing Research, the cleft-palate problem in orthodontics is receiving considerable attention at the moment. These cases are being treated by a variety of methods from the edgewise arch to simple removable apparatus. In some instances there is considerable assistance in these projects from the State, but in Canada at Montreal I found a number of practitioners giving up part of their time to this treatment on a purely honorary basis. I am not sure that too much is being made of the number of people required to express an opinion on each case. These include a psychologist, a social worker, an orthodontist, a pedodontist, a pediatrician, a speech therapist, a plastic surgeon, and an E.N.T. surgeon. I believe that after a time a team of three clinicians can really assess these cases properly although consultation must be available with the others. There is a great tendency to attempt to delay the surgical closure of the soft palate until 5 to 6 years of age, but this is bound to be a controversial point, as it is in this

country. Most of these Cleft Palate Clinics have or are acquiring extremely good physical facilities.

I have tried to give a general appraisal of my impressions of this visit and time does not permit me to elaborate. I made so many friends and received so much kindness and hospitality that I cannot possibly make reference to everybody. If I have been somewhat critical of certain things, I must point out how much I admire their industry and ideals and their intense interest in the subject. There are bound to be differences of opinion in orthodontic viewpoints and I hope I have played some small part in bridging the gap between our different ways of thinking. I hope in the future that there will be a steady interchange of visitors between our two countries.

To summarize my impressions:—

1. There is definitely an increase of undergraduate orthodontic training.

2. Very full graduate programmes are given at most schools, covering anything up to two years' full-time study.

3. Cephalometric research is still active but it is no longer quite so dominant as a diagnostic tool.

4. There is an ever-increasing interest in soft-tissue behaviour, as shown by the number of workers in the field of electromyography.

5. There is a slight increaese in the use of removable appliances.

Acknowledgements.—My thanks are due to the Dental Council of Guy's Hospital Dental School for the grant which enabled me to make this visit; to all my many friends in the United States and Canada who made me so welcome and helped me in so many ways; to Mrs. Rawlins who has prepared the X-ray tracings for photographing; and to Miss Whiteley for the preparation of the slides.

DISCUSSION

Miss D. R. Ridley thanked Mr. Tulley for his most interesting paper. She was fortunate enough, she said, to be in the United States of America at the same time as Mr. Tulley and was able to attend his lecture at the Annual Meeting of the American Association of Orthodontists in Boston. Unfortunately, they did not allow time for discussion after papers read at this meeting, but she had noted from subsequent remarks that the paper was received with obvious interest.

Generally speaking, little was known in the United States of America about British work in orthodontics, and she was repeatedly asked why the British Society for the Study of Orthodontics did not have a periodical of its own.

As Mr. Tulley remarked, orthodontics was mainly a postgraduate subject in the United States of America. Of the recent graduates from representative dental schools whom she questioned on the subject all admitted that only an extremely limited knowledge of orthodontics had been imparted to them as undergraduates.

The graduate courses, however, seemed to be excellent but expensive. The main emphasis in these was on diagnosis, from cephalometric and model analyses, and treatment with edgewise appliances. Little was taught about muscle activity or removable appliance therapy.

The brilliant concept of a television course, especially that of a closed circuit, showed, she thought, the typical enthusiasm and ingenuity of the American approach to a problem.

There was much more encouragement to embark on a research project in the United States of America than in this country but, of course, there was considerably more money available for research there.

As Mr. Tulley mentioned, each candidate for the Master's degree must report on some original work. Also the American Association of Orthodontists devoted part of its annual meeting to ten-minute reports on research work. Although some of these might be limited, they formed a contribution which might be useful in future investigations.

Mr. Tulley said that Dr. Broadbent was assessing growth potential by using frontal as well as lateral X rays. She wondered if he could say what method Dr. Broadbent used to analyse these frontal radiographs of the skull.

On the subject of electromyography, it was interesting to hear of Dr. Pruzansky's observations. Did Mr. Tulley conclude from this that it would be better not to use reference electrodes? And did he find that American investigators were obtaining better results with monopolar or bipolar electrodes?

The speed with which a whole mouth could be "strapped up" in the United States was, she thought, mainly due to the equipment available. The dental companies produced band material ready cut and contoured for the various teeth, with or without attachments as desired. She had found these particularly useful with canines. Preformed arches of various types might be obtained and a large variety of ready-made hooks and attachments.

She was interested to hear that the Adams clasp was used in the University of Montreal, as she did not see it in use in the United States.

She noticed, like Mr. Tulley, the tendency for early treatment of Class II, Division 1 cases with a Hawley bite-plate and head-gear. She was informed that the

treatment was given not to retract the maxillary buccal segments but rather to hold back the maxillary arch in its position, while the mandible with the mandibular arch was allowed to grow forward. She wondered whether Mr. Tulley had heard any different ideas on this subject.

She was surprised to find that the children in Rochester, New York, looked very like the children she had been treating in London and that problems of treatment were very similar. It was interesting to note that many of these children together with those from the New England States were mainly of British ancestry, while those from the Middle West were chiefly of Central European origin. That much of the literature had been from the Middle West was probably the reason why there was a tendency to assume that all American children suffered from a double proclination.

In conclusion, she would like to thank Mr. Tulley once again for a very enjoyable paper.

Professor C. F. Ballard said it was interesting to note that the cases of successful treatment without extractions discussed by Mr. Tulley were all of the same type, if one assessed their soft-tissue morphology. They were in fact the types one would associate with a Central European origin. It was also interesting to note that these Central European individuals had longer maxillas than were found in this country. It was the type of case in which a result could be obtained that remained stable without extraction.

Mr. R. E. Rix, after thanking Mr. Tulley for his interesting paper, said he had touched on the work of Ricketts and his confrères who were studying the temporomandibular joint but did not enlarge upon their findings. He would be interested to hear whether they were investigating further the alleged high frequency of distal displacements in Class II, Divisions 1 and 2, that were written up a year or so previously.

The President said he was interested in Mr. Tulley's remarks about cephalometric research. Mr. Tulley had said that the Americans were becoming more interested in soft-tissue behaviour, as evidenced in their increasing use of electromyography. Did they do what had been done in this country—indulge in large-scale clinical observation? This must be the first step in dealing with soft-tissue morphology and behaviour before engaging in complicated electromyography and scientific research.

It struck him very much that the Americans had, in their orthodontic outlook since Angle, been pure environmentalists. Angle taught that the position of the teeth and the size of the jaws was environmental. The jaws grew according to the teeth. Cephalometrics had disproved Angle's original dogmata but they seemed to be still trying to apply Angle's basic principle of environmentalism to electromyography and muscle behaviour and not trying to get down to basic developmental and genetic constitutional factors.

He said he disliked the expression 'growth potential'. It indicated that there was some sort of growth potential which could be brought out by orthodontic treatment. 'Growth trend' was the right expression. Everyone knew that skeletal patterns might change during their development, though one could seldom tell in what direction. These changes might be adverse or favourable, but it was not the treatment that brought them about. There was something inherent in the child. He would like Mr. Tulley's comments on these observations.

Mr. Tulley, in reply, thanked Miss Ridley for a very clear opening to the discussion.

With regard to research in relation to the Master's degree, admittedly valuable contributions were made to orthodontic thought, and any research that could be done should be encouraged. He felt it was a great shame that so many of these men would go into general practice, starting with a mechanistic approach, and would never think back to their more scientific investigations of the past. A proportion of the papers in the American journal were of this nature ; there were many others, of course, which were not.

As Miss Ridley had said, research was encouraged and was most prolific, and the money was available.

He wished to see more encouragement for research in Britain.

With regard to Dr. Broadbent's frontal pictures, he had no special method of analysis. He superimposed traces for two or three years and got a general feeling of the growth trend.

Dr. Pruzansky had come to the same conclusion as he had—that bipolar electrodes probably gave a better representation than any other method of the gross picture of what was happening beneath and between the electrodes. Other people would disagree.

With regard to the preformed bands and attachments, many of the older men scorned "strapping up" with these. In the schools they had to do it the hard way, but in practice some of the younger men took full advantage of the preformed elements.

Dr. Alton Moore had given a paper on Class II, Division 1 treatment and had posed the question with regard to cervical traction : "Do we hold the maxillary teeth still while the mandible grows?" Do we restrict the growth of the maxilla, or what do we do? His conclusions were indefinite. Some cases showed one tendency and others another.

No one could really say how the X rays should be superimposed. It was possible to prove whichever one liked. The only method would be to have a series of identical twins and to treat one group by one method and the other by the other method, or leave one group alone. This was rather unlikely to happen.

He entirely agreed with Professor Ballard's comment. Difficult problems of oromuscular behaviour arose and this might be a partial answer to the questions raised about clinical appraisal which he would deal with in a moment.

In reply to Mr. Rix, he said Ricketts had gone to California now and his material was mainly at the Illinois School, where he did most of his work. He was not doing as much on the temporomandibular joint now. He was, however, working on cleft palates.

In reply to Mr. Hovell, Mr. Tulley said, generally speaking, with a number of exceptions the approach to treatment was a mechanistic one. The teeth were repositioned and it was assumed that the muscular forces would readapt to the occlusion.

"Growth potential" was perhaps not a good expression. Dr. Broadbent had always referred to "growth trends". Growth potentials could not be assessed. One could only thank God for growth potential if it was there.

He would like to sum up by saying that he realized that in a short paper of this kind one could not really tackle all the points which should be brought in. Perhaps he should have concentrated on one aspect, namely research. He had, however, tried to give a general impression and a fair assessment of the subject-matter as he saw it.

The President thanked Mr. Tulley for a most interesting Paper and for his reply to the discussion, Miss Ridley for opening the discussion, and all those who took part in it. (*Applause.*)

Professor G. E. M. Hallett said that this was the end of another year of Society meetings. He had very great pleasure in proposing, on behalf of the Society, their thanks to John Hovell for the splendid way in which he had occupied the Presidential Chair during the past year. He was particularly happy to do so because it was during this year and under Mr. Hovell's presidency that the Society held its country, or some people might say provincial, meeting in Newcastle. It had fallen to him and to his Newcastle colleagues to have rather more contact with Mr. Hovell than would perhaps have happened in the ordinary way. He was very much indebted to him for his interest and co-operation, which helped so much to make the meeting a success, as he believed it was.

Presidents—he supposed—occupied Chairs for a variety of reasons. Some occupied them because they had grown sage and venerable in the counsels of their Society; others because they had contributed much to the basic architecture of the Society; very occasionally because they were safer there than in any other position; sometimes because they had contributed notably to specialist knowledge; very rarely because they were naturally good Chairmen. Every now and then a President was found with more than one of these qualifications. Indeed, he might be the fortunate possessor of several. Mr. Hovell was certainly not elderly or venerable, but he had contributed to the architecture of the Society, if not to the splendid foundations to their renovation perhaps—should he say—of the administrative body. His natural iconoclasm had not only found outlet in coping with the Society's articles. He had also given evidence of vigorous participation in the revolutionary changes that orthodontic thought had undergone in the past fifteen years. If anyone thought the Presidency would fetter him to any extent they had been mistaken.

Those who had followed dental matters outside orthodontics would not have been entirely oblivious that whilst guiding the Society and holding the reins in one hand, he had been quite active with the other, discharging various shots and bolts which had produced in the dental world what might be described as a marked reaction.

Lastly, he had shown himself to be a genial host and a firm Chairman, one who had helped the Society both constructively and permanently.

For all these services they were very grateful and offered him their unstinted appreciation.

The President thanked Professor Hallett for what he had said. He hoped his tongue was not too much in his cheek when he said them, but it was very nice to hear them.

The words "Valedictory Address" appeared on his notes, but he did not propose to make one, because there was nothing worse than to talk when one was going out—or perhaps not going out but going off.

He now had the very pleasant task of introducing the new President, Professor Ballard, and would ask him to come up to receive the badge of office.

He then inducted Professor Ballard into his new office as President of the Society for the coming year.

Professor Ballard thanked the meeting and declared the meeting closed.

REPORTS OF MEETINGS

ORDINARY MEETING, January 9

An Ordinary Meeting of the Socicty was held at Manson House, 26, Portland Place, London, W.1, on Monday, January 9, 1956, at 7.30 p.m. Mr. J. H. Hovell, the President, occupied the Chair.

The Minutes of the Annual General Meeting held on Monday, December 12, 1955, were read, confirmed, and signed.

The following candidates for membership of the Society were elected *en bloc* by show of hands:—

Mr. D. J. Anderson, B.D.S. (Lond.), L.D.S. R.C.S. (Eng.), M.Sc., Ph.D. (Lond.), Department of Physiology, Guy's Hospital Medical School, London Bridge, London, S.E.1;

Mr. M. H. Booth, B.D.S. (Sheff.), L.D.S. R.C.S. (Eng.), 84, Rodney Street, Liverpool 1;

Mr. R. A. Campbell, B.D.Sc. (Melb.), D.Orth., c/o Regional Dental Office, Ministry of Health, 41, Tothill Street, London, S.W.1;

Mr. E. J. S. Clifford, L.D.S. (Manch.), c/o H. G. Watkin, 84, Rodney Street, Liverpool 1;

Miss J. M. Crowther, L.D.S. (Manch.), 22, Beaumont Street, Oxford;

Mr. A. J. Cruickshank, L.D.S. (Manch.), 48, King Street, Manchester 2;

Mr. H. C. Martin, B.D.S. (Lond.), L.D.S. R.C.S. (Eng.), Pond House, Firs Walk, Woodford Green, Essex;

Miss R. M. Priestley, L.D.S. (Dunelm.), 5, The Crescent, Scarborough, Yorkshire;

Mr. D. Robertson-Ritchie, L.D.S. R.C.S. (Eng.), H.D.D. (Edin.), Market House, Market Avenue, Chichester, Sussex.

The President welcomed the visitors who were present and asked them to consider themselves members of the Society for the evening and to take part in the discussion if they wished to do so.

The President then delivered the Presidential Address:—

"*The New Look in Orthodontics*"

ORDINARY MEETING, February 13

An Ordinary Meeting of the Society was held at Manson House, 26, Portland Place, London, W.1, on Monday, February 13, 1956, at 7.30 p.m. Mr. J. H. Hovell, the President, occupied the Chair.

The Minutes of the January Ordinary Meeting were read and confirmed.

One member (Mr. Booth), attending for the first time, was introduced to the President.

The following six candidates for membership of the Society were elected *en bloc* by show of hands:—

Mr. C. P. Blackmore-Reed, L.D.S. R.C.S. (Eng.), Tudor House, 372, Wickham Road, Shirley, Croydon, Surrey;

Mr. B. Boyd-Cooper, L.D.S. R.C.S. (Eng.), M.R.C.S., L.R.C.P., 11, Watford Road, King's Langley, Herts.;

Mr. M. Cutler, L.D.S. (B'ham), Municipal Bank Buildings, Six Ways, Erdington, Birmingham 23;

Mrs. J. Frazer, B.Ch.D., L.D.S. (Leeds), D.Orth., The Royal Dental Hospital, Leicester Square, London, W.C.2;

Mr. H. Pogrel, L.D.S. (L'pool), Grayton, County Road North, Ormskirk, Lancashire;

Mr. R. Wallis, L.D.S. R.C.S. (Eng.), Buckingham House, Graham Road, Malvern, Worcestershire.

The President then welcomed any visitors who might be present, and asked them to regard themselves as members for the evening.

Mr. E. S. Broadway then delivered his casual communication:—

"*Backward Displacement of the Proximal Interphalangeal Joints of the Third and Fourth Fingers resulting from Finger Sucking*"

The President, in welcoming Mr. Grossmann, from the National Dental Hospital, and Mr. Greenfield, of the Royal College of Surgeons, expressed the view that the title probably did not do justice to the interest of the paper.

Mr. B. E. Greenfield and Mr. W. Grossmann then delivered the following Paper:—

"*An Analysis of Treated Cases*"

ORDINARY MEETING, March 12

An Ordinary Meeting of the Society was held at Manson House, 26, Portland Place, London, W.1, on Monday, March 12, at 7.30

p.m. Mr. J. H. Hovell, the President, occupied the Chair.

The Minutes of the previous Ordinary Meeting, held on February 13, 1956, were read, confirmed, and signed.

The Hon. Secretary announced that a new dental journal was now being published in America. It was entitled *Dental Abstracts* and contained selections from world dental literature. It could be obtained from the American Dental Association, and subscriptions for it should be sent to that Association.

The following recently elected members were admitted to membership by the President: Mr. B. Boyd-Cooper and Mr. D. H. T. M. Robertson-Ritchie.

The following candidates for membership of the Society were elected *en bloc* by show of hands :—

Mr. S. H. Alexander, B.D.S., L.D.S. (Sheff.), 28, Hoyland Road, Hoyland Common, near Barnsley, Yorkshire;

Mr. A. G. T. Allcorn, L.D.S. R.C.S. (Eng.), 7, Ocklynge Avenue, Eastbourne, Sussex;

Mr. G. C. Christian, L.D.S. R.C.S. (Eng.), 6, Dartford Road, Sevenoaks, Kent;

Mr. W. R. Graves-Morris, L.D.S. R.C.S. (Eng.), 25, Southfields Road, Eastbourne, Sussex;

Mr. P. M. C. James, L.D.S. R.C.S. (Eng.), D.P.D. (St. Andrews), Bull Farm House, Park Lane, Beaconsfield, Buckinghamshire;

Mr. R. J. Sharland M.B., B.S., B.D.S. (Lond.), F.D.S. R.C.S. (Eng.), 132, Denmark Hill, London, S.E.5;

Mr. A. R. Widdowson, B.D.S. (L'pool), 41, Caldy Road, West Kirby, Wirral, Cheshire.

The President welcomed the visitors who were present and asked them to consider themselves as members of the Society for the evening and to take part in any discussion if they wished to do so.

Mr. Norman Wild then read the following short communication:—

"*Fistulæ of the Lips*"

During the discussion on this communication the President asked whether Mr. Wild had considered injecting lipiodol in order to show up the fistula radiographically.

Mr. Wild said that he had tried to inject it into the fistula but he had not been able to obtain any definite result.

On the motion of the President, a vote of thanks was accorded to Mr. Wild for his communication.

The following Paper was then read by Miss E. M. Bonnar:—

"*Aspects from the Transition from Deciduous to Permanent Dentition*"

COUNTRY MEETING, May 10–12

A Country Meeting of the Society was held at the Sutherland Dental School, Newcastle upon Tyne, on Thursday, Friday, and Saturday, May 10–12.

For the morning session on Friday, May 11, the President, Mr. J. H. Hovell, took the Chair at 9.15 a.m.

Welcoming members to the second Country Meeting the Chairman said the Society owed its thanks to Professor R. V. Bradlaw for providing the facilities for the meeting, and to his staff, and in particular Professor Hallett, for the amount of work they had done in arranging things.

Professor R. V. Bradlaw said the Portuguese had a rather charming proverb, that visits always gave pleasure, if not the coming then the going. He need hardly say that so far as the Sutherland Dental School was concerned it was the coming of the members of the Society which had given them pleasure, and they would view their going with regret. The University was delighted that the second Country Meeting of the Society should be held in Newcastle and they were particularly welcome because their subject had always been held to be of especial importance in that University, as would be evident from the institution of a Chair in the subject.

The speciality of the Society had its beginnings with those of dental surgery as it was now conceived. If one discounted the observations of Cornelius Celsus and Galen, for one could not legitimately regard either of those, or the rough orthodontic measures of the Arabian, Abul Casis, as the beginnings of the art, there was undoubtedly a substantial body

of thought and endeavour in that field before Pierre Fouchard, whose likeness adorned the Presidential badge of office, described orthodontic appliances which he used. From that time on, a number of writers had included chapters on irregularities of the teeth, among them persons no less than Hunter and Fox, but it was not until Kingsley in the United States of America, and Gaine in Bath, wrote whole works devoted to the speciality that it came into its own. It was probably true to say that at the turn of the century until Edward Angle, who had devoted great thought to the subject, published his classical work there were few who specialized entirely in it. Angle's work stimulated new thought and the formation of a number of societies devoted to promoting it, among them being the British Society for the Study of Orthodontics.

The founders of the Society were men like Northcroft, Mellersh, Lockett, Chapman, Rushton, and Badcock, and for nearly half a century its members had met together, not to protect vested interests or to enforce privilege but to advance and disseminate scientific knowledge and to encourage the highest ideals of service to the community.

To-day in this country the orthodontist took his place by the side of other specialists in the art of healing: his position was recognized, his skill and his ability appreciated, and to that in no small measure the activities of the Society had contributed. At no other time had it been so necessary to preserve standards, and to ensure that excellence was not sacrificed to expediency.

Concluding his remarks, Professor Bradlaw said he was proud to welcome such a distinguished Society to the University of Durham, and sincerely hoped that the meeting would be an outstanding success.

The CHAIRMAN thanked Professor Bradlaw for his kind and hospitable welcome and expressed the hope that the University would really and sincerely regret their going as they had welcomed the Society's coming. Professor Bradlaw's welcome, given in his usual inimitable and erudite fashion, had pleased them all very much and every member present would wish to say "thank you" to him.

The Minutes of the last meeting were read and confirmed.

The CHAIRMAN welcomed any visitors who might be present and asked them to consider themselves as members of the Society for the meeting and to take part in the discussions should they so wish.

Members who were attending for the first time were introduced to the President.

The following candidates for election were admitted *en bloc* by a show of hands:—

Mr. W. R. Booth, L.D.S. R.C.S. (Eng.), 67, Thorne Road, Doncaster, Yorkshire;

Mr. G. E. Frost, L.D.S. R.C.S. (Eng.), 1, Brooklyn Avenue, Layton, Blackpool, Lancashire;

Mr. C. Bowdler Henry, M.R.C.S., L.R.C.P., F.D.S. R.C.S. (Eng.), 62, Harley Street, London, W.1;

Mr. L. M. Irwin, L.D.S. R.C.S. (Eng.), 29, High Street, Sandwich, Kent;

Mr. J. Kurer, M.D. (Vienna), L.D.S. R.C.S. (Eng.), 28, Deansgate, Manchester 3, Lancashire;

Mr. J. T. Powell-Cullingford, L.D.S. R.C.S. (Eng.), 58, Baldwin Ave., Eastbourne, Sussex;

Mr. D. Greer Walker, M.A., M.B., B.Ch., B.A.O., M.Dent.Sc., F.D.S. R.C.S. (Eng.), The Paddocks, Boyn Hill Avenue, Maidenhead, Berkshire;

Miss J. Weyman, B.D.S. (Dunelm.), F.D.S. R.C.S. (Eng.), D.Orth. R.C.S. (Eng.), 39, Hillcrest, Whitley Bay, Northumberland;

Mr. W. E. Woolcott, "Gold's Place", Cullompton, Devon.

Introducing the reader of the opening Paper the CHAIRMAN said it was only right that it should be Professor Hallett, Professor of Children's Dentistry in the University of Durham.

PROFESSOR G. E. M. HALLETT then delivered his Paper:—

"*Immediate Torsion: A Preliminary Report on Twenty-three Cases*"

The following Paper was delivered by MR. D. MUNRO:—

"*Thumb- and Finger-sucking*"

MR. D. GREER WALKER then read his Paper entitled:—

"*The Mandibular Condyle*"

This was followed by the Paper read by Mr. H. E. Wilson:—

"*Early Recognition of Some Aetiological Factors in Temporomandibular Joint Disorders*"

The Saturday morning session was comprised of a Symposium on Class II division 1 Malocclusion.

The first Paper, delivered by Mr. C. F. Ballard, was entitled:—

"*Morphology in Relation to Treatment Planning*"

Mr. W. H. Littlefield then read the second Paper:—

"*Treatment*"

Short Communications by Mr. A. C. Campbell, Mr. J. S. Rose, and Mr. S. G. McCallin were then given. These were:—

"*Treated Cases*"

For the first part of the Session the Chair was taken by the President, Mr. J. H. Hovell, and afterwards by Professor G. E. M. Hallett.

The Chairman (Professor G. E. M. Hallett), in thanking the contributors for their communications, apologized for the fact that they had been pressed for time and said it had probably been a mistake to put them in at that point in the programme because it left no opportunity for discussion and he personally felt that the contributions were very valuable.

In the absence of the President he wished formally to close the meeting, except for the demonstrations, and to say on behalf of himself and Professor Bradlaw how much they had enjoyed the meetings. It had been great fun and the School had got a lot out of it, and, in the hope that the Provincial Meetings would beeome established they were looking forward in the future to seeing the members in Newcastle again, after they had been round the other Schools and towns.

On the Saturday afternoon Table Demonstrations were given by Mr. G. C. Dickson, Professor G. E. M. Hallett and Mr. P. H. Burke, Messrs. D. T. Hartley, R. O. Hellier, G. B. Hopkin, W. Trevor Johnson, H. L. Leech, Mr. B. C. Leighton and Miss D. E. M. Warner, Messrs. J. D. McEwen, J. R. E. Mills, J. C. Ritchie, G. H. Roberts, and Miss J. Weyman.

The President said unfortunately he had to be in London that evening for the Annual Dinner of the Royal Dental Hospital, as also did Mr. Ballard, and apologized for leaving before the end of the morning meeting.

Since he would not be there to wind up the proceedings he wished at that stage to congratulate the staff of the Hospital upon the excellent dinner which they had produced the previous evening.

ORDINARY MEETING, October 8

An Ordinary Meeting of the Society was held at Manson House, 26, Portland Place, London, W.1, on Monday, October 8, 1956, at 7.30 p.m. The President, Mr. J. H. Hovell, occupied the Chair.

The Minutes of the Country Meeting held on May 11 and 12 were read and confirmed.

The President said that he had, with regret, to announce the death of two old members. One was Mr. H. Shaw, who was the orthodontist at Leeds. The other was Mr. J. E. Spiller, an old Guy's man, who had held office in the Society as Librarian, and was President from 1916 to 1919.

The meeting stood in silence as a mark of respect to the two former members.

Three members—Miss Weyman, Mr. Booth, and Mr. Martin—who were attending for the first time were introduced to the President.

The following seven candidates for election were admitted *en bloc* by a show of hands:—

Mr. J. T. Cook, B.D.S. (Dunelm.), 277, Broadway, Cullercoats, Northumberland.

Mr. G. H. Dakers, L.D.S. R.C.S. (Eng.), 4, The Square, Crawley, Sussex;

Mr. P. L. Foster, L.D.S. R.C.S. (Edin.), 40, Spencer Road, Belper, Derbyshire;

Mr. M. S. E. Gould, B.D.S. (Lond.), L.D.S. R.C.S. (Eng.), Oak Lodge, 5, Waverley Road, Enfield, Middlesex;

Mr. A. R. Grice, B.D.S. (Lond.), L.D.S. R.C.S. (Eng.), 16, Montague Gardens, West Acton, London, W.3;

Mr. D. A. Plint, B.D.S. (Rand), F.D.S. R.C.S. (Eng.), 24, Manorgate Road, Kingston upon Thames, Surrey;

Mr. G. H. Steel, B.D.S. (Dunelm.), F.D.S. R.C.S. (Eng.), 99, Sunderland Road, South Shields, Co. Durham.

The PRESIDENT then welcomed the unusually large number of visitors and asked them to regard themselves as members and take part in the discussion.

Mr. G. B. Hopkin and Mr. J. D. McEwen then presented the following Paper:—

"*Speech and the Orthodontist*"

ORDINARY MEETING, November 12

AN ORDINARY MEETING of the Society was held at Manson House, 26, Portland Place, London, W.1, on Monday, November 12, 1956, at 7.30 p.m. The President, Mr. J. H. Hovell, occupied the Chair.

The Minutes of the meeting held on Monday, October 8, 1956, were read and confirmed.

Three members—Mr. Dakers, Mr. Gould, and Mr. Grice—who were attending for the first time were introduced to the President.

The following ten candidates for election were admitted *en bloc* by a show of hands:—

Mr. W. A. B. Brown, L.D.S. R.C.S. (Eng.), D.Orth., 67, Harley Street, London, W.1;

Mr. D. K. Hardy, L.D.S. R.C.S. (Eng.), 1, Castelnau, Barnes, London, S.W.13;

Mr. J. J. Jeffreys, L.D.S. R.C.S. (Eng.), 22, Lytton Grove, Putney Hill, London, S.W.15;

Mr. D. W. Martin, B.D.S. (L'pool), L.D.S. R.C.S. (Eng.), 5, Parkway, Ratton, Eastbourne, Sussex;

Mr. D. H. Oliver, L.D.S. R.C.S. (Eng.), 1, Downes Court, Winchmore Hill, London, N.21;

Mr. H. E. Sandiford, L.D.S. (Manc.), 20, Albemarle Road, Beckenham, Kent;

Mrs. B. M. A. Turner, B.D.S. (Manc.), L.D.S. (Manc.), D.Orth., Wayside, 36, Styal Road, Wilmslow, Cheshire;

Mr. C. K. Cheah, B.D.S. (Malaya), F.D.S. R.C.S. (Eng.), D.Orth., University of Malaya, Dental Clinic, General Hospital, Singapore (Corresponding Member);

Mr. P. H. Demoge, 19, Boulevard Wilson, Dole, Jura, France (Corresponding Member);

Dr. H. T. Oliver, D.D.S., 1414, Drummond Street, Montreal 25, Quebec, Canada (Corresponding Member).

The PRESIDENT then welcomed any visitors who were present and asked them to regard themselves as members of the Society for the evening and to take part, should they wish to do so, in any discussion which might follow the paper.

Introducing the author of the Tenth Northcroft Memorial Lecture the President said Professor R. J. Harrison, Professor of Anatomy at the London Hospital, was well-known for his interest in, and the many papers he had written on, anatomy and particularly embryology and comparative anatomy.

Professor R. J. Harrison then delivered his lecture on:—

"*Nature and Nurture in Jaw Development*"

ANNUAL GENERAL MEETING, December 10

THE ANNUAL GENERAL MEETING of the Society was held at Manson House, 26, Portland Place, London, W.1, on Monday, December 10, 1956, at 7 p.m. The President, Mr. J. H. Hovell, occupied the Chair.

The Minutes of the Ordinary Meeting held on Monday, November 12, 1956, were read, confirmed, and signed.

Revision of the Society's By-laws.—

The PRESIDENT said that the present By-laws had been in existence since 1907 with only sporadic minor revisions. It was found that occasions kept arising upon which the by-laws were inadequate, and the Council also felt that its own situation was perhaps not that which was quite right for a Society of this size. A Subcommittee under the Chairmanship of Mr. Pringle therefore put in a great deal of very hard work in revising the By-laws and had suggested alterations in the constitution of the Council and the Society. These had all been circulated, and it was hoped would meet with approval, so that they could be confirmed that evening and put into being.

The Circular giving the amendments had been amended in two small respects at the meeting of the Council held that evening.

On page 1, the word "and" had been deleted after "Distinguished Overseas Practitioners of Dentistry" in paragraph 2. This was purely a matter of grammar.

On page 2, the words "in this office" had been added after "No Councillor shall serve more than three years in succession" in By-law XVII, sub-section v.

He would be pleased to answer any questions that might be put to him to the best of his ability before it was proposed that the By-laws be adopted.

Mr. H. E. WILSON said he was sorry he had been unable to comply with the Secretary's request that queries be conveyed to him in writing before the meeting.

On page 2, in By-law XV, there were the words "At least three members of the Council shall be resident outside the London area". He himself was resident outside the London area, the postal area, but he practised in the London area. He did not think this was the intention of the Council and he thought the By-law should be worded differently. He had no alternative wording to propose, but perhaps a reference should be made to people practising or not practising inside the London area.

The PRESIDENT said that the Council did consider this point, and Mr. Wilson was right in suggesting that it was the intention of the Council that these people should not be practising in the London area. But the term "London area" was very wide and it was definitely felt to include the Home Counties. It was desired to avoid making the By-law inelastic and the words "outside the London area" implied that these practitioners should be representative of the more farflung corners of England.

He did not think any purpose would be served by referring the proposal back to the Council, but thought the wording should remain as it stood.

MR. WILSON said he appreciated the problem. He was thinking of the position ten years hence, when the present Council had dropped away and someone might say he was resident outside the London area and came into this category. He had no wish to question the wisdom of the Council.

The PRESIDENT said that while he saw the point, when it came to practical politics the Council would normally be drawn from young people and not retired people who were residing in the more remote parts of England.

If Mr. Wilson wished to press the point, he was at liberty to do so, but the By-law would then have to be referred back to the Council for consideration. He could assure Mr. Wilson that the point was raised and had been considered.

A Member asked whether the term "London area" meant anything in legal parlance.

The PRESIDENT said that the Council did not think so, that was why the wording was acceptable.

Mrs. M. E. H. DAVIS said that whether people resided or practised in the London area would be judged from the addresses given in the list of Members.

The PRESIDENT said that that was the feeling. The By-law could be left vague, he thought, so that it could be obeyed in the spirit.

Mrs. DAVIS asked whether the quorum referred to in By-law XXXIII should not be five instead of three.

The PRESIDENT said that this point was raised at the Council meeting that evening. There were occasions—and one had arisen recently—when it was necessary for the President to make a rather hasty emergency decision. The usual procedure was for the President to consult with the Secretary and Treasurer. That was the reason for taking three as a quorum.

The Council did feel, however, that if the general body of the meeting thought the quorum should be enlarged to five there would be no objection to this. The matter having been considered beforehand, an enlargement of the quorum from three to five could be accepted if that was the wish of the meeting.

The Council did not think that it was necessary, because the situation only arose very occasionally, for instance, with regard to emergency decisions on how much the cost of a dinner ticket should be and such matters. It would not affect the entire future of the Society. Obviously, any decision made in this way was a decision which had to be implemented before the next Council meeting.

If the Annual General Meeting felt the quorum should be enlarged, he would be happy to accept a motion from a proposer and seconder to that effect.

Mr. H. Chapman said that as a practical matter three was satisfactory. It meant that the President, Secretary, and Treasurer could deal with any business. In the first world war there were occasional meetings and if five had been the quorum nothing could have been done.

The President asked whether Mrs. Davis wished to press the matter to a vote now that he had explained the position. Matters of policy would not be affected but only minor decisions.

Mrs. Davis: No.

Mr. Wilson said he was sorry to speak again, but he was raising one point at a time. He had intended to raise the point referred to by Mrs. Davis and he would like to take it further. If he was in order he would propose that the quorum be raised to five.

The President asked whether there was a seconder.

Mrs. Davis seconded the motion.

The President pointed out that an amendment had been proposed to the amended By-laws which would have to be carried, according to the existing By-laws, by a two-thirds majority. This was what he believed was termed in the House of Commons a free vote.

Mr. J. S. Beresford observed that some people might have overlooked that a quorum was the number of people who appeared after all the members had been duly notified that a meeting was called. In case anyone had the idea that it was a question of the President ringing up two colleagues he thought it should be pointed out that it meant a meeting. The quorum was the number of people who actually turned up after everyone had been told there was to be a meeting.

The President said he thought the issue was clear.

The motion was put to the vote and was defeated.

Mr. Wilson drew attention to By-law XLIII (to become XLII), paragraph viii, which said that the discussion being closed, the President should express the thanks of the Society to the Author for his Paper. He pointed out that on occasions there were casual communications. Would it not be more correct to thank the Authors for their Papers?

The President said that this was a matter of words. Every President had, as occasion demanded, thanked the Author and those who had taken part in the discussion. It did not actually appear in the By-laws that he should thank those who had taken part in the discussion, but he usually did so. No doubt Mr. Wilson was technically correct. Did he wish to press this to a division?

Mr. Wilson signified that he did not wish to do so.

The President said Mr. Wilson was obviously correct: this was one of the things one hoped the President would have enough common sense to realize.

There being no further comments, the President proposed from the Chair that the By-laws be adopted by the Society. He asked all present to vote either for or against the motion in order to give a consensus of opinion.

The motion was put to the vote and was carried nem. con.

Election of Officers and Councillors.—The President said that in the hope—or perhaps he should say in anticipation—of the By-laws being passed, the Council had seen fit to make provisional nominations for the ensuing year. As members were aware, there were several new offices under the revised By-laws.

These nominations having been put forward by the Council and no counter nominations having been received, he declared the persons named duly elected.

Election of Two Auditors.—The President said that Mr. Newton and Mr. Winn had acted as Auditors for some years and had given the Society a lot of help and some useful advice during that period. He invited proposals from members.

On the motion of Professor C. F. Ballard, who was seconded by Mr. H. E. Wilson, Mr. Newton and Mr. Winn were re-elected as Auditors for the year 1957.

Report of the Hon. Treasurer.—The Hon. Treasurer (Mr. J. S. Beresford) presented his report as follows :—

The excess of Income over Expenditure is an improvement upon last year's figure. The cost of the 1955 Transactions which have already been published is not yet known and the reserve has been based upon last year's cost. The figures for the Country Meeting do not take into account the high cost of reporting and the increase in the price of the Transactions which resulted from the extra papers published. My thanks are again due to the Hon. Librarian for a very handsome credit arising from the sale of Transactions.

On the motion of Mr. Beresford, seconded by Mr. Walther, the report was received.

A motion by the President from the Chair that the report be adopted was carried.

Report of the Hon. Secretary.—The Hon. Secretary (Mr. H. L. Leech) presented his report, as follows :—

In the twelve months from December, 1955, to November, 1956, eight meetings of the Society have been held with an average attendance of 86 members and visitors per meeting.

This again represents a slight drop in the figures for the previous year. However, during the year 49 new members have been elected, which is well over double those for the previous year and the highest figure for many years. There have been 7 resignations and 3 deaths, and the membership as at December 31, 1956, is expected to be 450. The method of presenting the Members List was revised at the beginning of the year.

The second Country Meeting of the Society was held at Newcastle upon Tyne in May, and took the form of a two-day conference. The amenities of the Sutherland Dental Hospital were very kindly placed at the Society's disposal by permission of the Dean, Professor R. V. Bradlaw, who opened the Meeting with an Address of Welcome. The Hon. Secretary is grateful to Professor G. E. M. Hallett for his expert help and co-operation in the local organization of the conference.

Six Papers were read, including a Symposium on Angle's Class II division 1 Malocclusion, and thirteen table demonstrations were given.

The Demonstration Meeting normally held in May was transferred to the afternoon of the October Meeting and, judging by the number of members attending, proved highly successful.

The By-laws have been completely revised and brought up to date by the Council, and await the approval of the Society.

On the motion of Mr. Leech, seconded by Professor G. E. M. Hallett, the report was received.

A motion by the President from the Chair that the report be adopted was carried.

Report from the Librarian.—The Hon. Secretary (Mr. H. L. Leech) presented the report of the Hon. Librarian (Mr. A. G. Taylor) who was unable to be present, as follows:—

The year 1956 has been quiet in the Library especially when compared with last year's record business.

The Society's thanks are due to Miss Clinch for the gift of the *European Orthodontic Society's Transactions* for 1935, 1937, and 1938, Sim Wallace's *Essay on the Irregularities of the Teeth*, and Pullen's *Orthodontic Impressions and Casts*.

Two books have been bought: C. P. Adams' *The Design and Construction of Removable Orthodontic Appliances*, and the Dental Board's *Ætiology of Irregularity and Malocclusion of the Teeth*. Of periodicals the library obtains by subscription or exchange *The Angle Orthodontist*, *The American Journal of Orthodontics*, *The Dental Practitioner and Dental Record*, *Dental Abstracts*, and the annual transactions of the European, French, and Spanish orthodontic societies.

Lastly, I make my annual appeal to members for out-of-print Transactions for 1924, 1927, and all of the 1940s.

On the motion of Mr. Leech, seconded by Mr. W. J. Tulley, the report was received.

A motion by the President from the Chair that the report be adopted was carried.

Report of the Hon. Editor.—The Hon. Editor (Mr. W. J. Tulley) presented his report, as follows:—

I am able to report that the 1955 *Transactions* are now completed and should have been received by all Members. These *Transactions* are unique in so far as they contain the Papers given at the first Country Meeting of the Society. I would like to emphasize again that the *Transactions* could be produced more quickly if writers would adhere to the ruling that they must pass their Paper to the Editor within seven days. If we are to get *Transactions* printed within the year, we will have to go to press without some Papers and this was regretfully true of the Northcroft Memorial Lecture last year.

There has recently been a twenty per cent increase in the cost of making small blocks and the Council are considering measures to be taken in this matter.

We have enjoyed over the past two years excellent liaison with Messrs. John Wright & Sons but they are becoming concerned about the length of some of our papers and my editorial leniency.

I would like to thank Professor C. F. Ballard and Mr. A. C. Campbell for so kindly holding the Editorial fort while I was in the United States.

On the motion of Mr. Tulley, seconded by Mr. J. S. Rose, the report was received.

A motion by the President from the Chair that the report be adopted was carried.

Report of the Hon. Curator.—The Hon. Curator (Miss L. M. Clinch) presented her report, as follows:—

The Museum is still situated in the Institute of Public Health and Hygiene (next door to Manson House) where the contents can be seen between 9.30 a.m. and 5 p.m. on weekdays. During the past year models have been received from Miss Still, Professor Hutchinson, and Mr. Townend. Old plates and appliances of interest have been received from Mr. Chapman and Professor Friel.

On the motion of Miss Clinch, seconded by Mrs. M. E. H. Davis, the report was received.

A motion by the President from the Chair that the report be adopted was carried.

Member Attending for the First Time since Election.—Mr. W. A. B. Brown, who was attending for the first time since his election, was introduced to the President.

Candidates for Election.—The following candidates for election were admitted together by show of hands:—

Mr. R. D. Howard, B.D.S. (Lond.), L.D.S. R.C.S. (Eng.), 20, Manor Farm Road, Alperton, Wembley, Middlesex;

Mr. G. D. Jameson, B.D.S. (Dunelm.), 12, Southend Avenue, Darlington, County Durham.

The President announced that that concluded the business of the Annual General Meeting, and visitors and guests could now be admitted.

This having been done, the President welcomed the visitors and asked them to consider themselves as members of the Society for the evening and to take part in the discussion after the Paper, if they wished.

In calling upon Mr. Tulley to present his Paper, he said that everyone knew the author and his work on electromyography, as well as his general ability as a member of the Society. It was a pleasure that he was now able to give his Paper which was unfortunately deferred last year.

Mr. W. J. Tulley delivered the following Paper:—

"*Report on a Visit to the U.S.A.*"

Professor G. E. M. Hallett said that this was the end of another year of Society meetings. He had very great pleasure in proposing, on behalf of the Society, their thanks to John Hovell for the splendid way in which he had occupied the Presidential Chair during the past year. He was particularly happy to do so because it was during this year and under Mr. Hovell's presidency that the Society held its country, or some people might say provincial, meeting in Newcastle. It had fallen to him and to his Newcastle colleagues to have rather more contact with Mr. Hovell than would perhaps have happened in the ordinary way. He was very much indebted to him for his interest and co-operation which helped so much to make the meeting a success, as he believed it was.

Presidents—he supposed—occupied Chairs for a variety of reasons. Some occupied them because they had grown sage and venerable in the counsels of their Society; others because they had contributed much to the basic architecture of the Society; very occasionally because they were safer there than in any other position; sometimes because they had contributed notably to specialist knowledge; very rarely because they were naturally good Chairmen. Every now and then a President was found with more than one of these qualifications. Indeed, he might be the fortunate possessor of several. Mr. Hovell was certainly not elderly or venerable, but he had contributed to the architecture of the Society, if not to the splendid foundations to their renovation perhaps—should he say—of the administrative body. His natural iconoclasm had not only found outlet in coping with the Society's articles. He had also given evidence of vigorous participation in the revolutionary changes that orthodontic thought had undergone in the past fifteen years. If anyone thought the Presidency would fetter him to any extent they had been mistaken.

Those who had followed dental matters outside orthodontics would not have been entirely oblivious that whilst guiding the Society and holding the reins in one hand, he had been quite active with the other, discharging various shots and bolts which had produced in the dental world what might be described as a marked reaction.

Lastly, he had shown himself to be a genial host and a firm Chairman, one who had helped the Society both constructively and permanently.

For all these services they were very grateful and offered him their unstinted appreciation.

The PRESIDENT thanked PROFESSOR HALLETT for what he had said. He hoped his tongue was not too much in his cheek when he said them, but it was very nice to hear them.

The words "Valedictory Address" appeared on his notes, but he did not propose to make one, because there was nothing worse than to talk when one was going out—or perhaps not going out but going off.

He now had the very pleasant task of introducing the new President, PROFESSOR BALLARD, and would ask him to come up to receive the badge of office.

He then inducted Professor Ballard into his new office as President of the Society for the coming year.

PROFESSOR BALLARD thanked the members for the honour they had conferred upon him and declared the meeting closed.

THE BRITISH SOCIETY FOR THE STUDY OF ORTHODONTICS

Balance Sheet and Income and Expenditure Account

FOR THE YEAR ENDED SEPTEMBER 30, 1956

FREDK. B. SMART & COMPANY, CHARTERED ACCOUNTANTS

22 Queen Street, London E.C.4

The British Society for the Study of Orthodontics

INCOME AND EXPENDITURE ACCOUNT for the year ended 30th September, 1956

1955									1955								
£	s.	d.		£	s.	d.	£	s.	d.	£	s.	d.		£	s.	d.	£	s.	d.
10	10	0	To Museum Rent				10	10	0				By *Members' Subscriptions:*—						
92	7	1	,, Printing and Stationery	95	4	4							1956 Subscriptions	1,206	11	11			
584	7	8	,, Reserve for Cost of *Transactions*	361	12	6							Adjustment in respect of Past Years	57	15	0			
–	–	–	,, Reserve for *Practitioner*	75	0	0											1,264	6	11
							531	16	10	1,141	14	0							
18	5	3	,, Postage	36	17	3				84	0	1	,, Sale of *Transactions*				131	3	2
1	5	0	,, Lantern and Film Expenses	5	0	0							,, Accrued Interest on Savings Certificates				12	10	0
46	13	0	,, Hire of Hall	46	13	0				12	10	0							
32	16	5	,, Reporting	31	5	3							,, Interest on $2\frac{1}{2}\%$ Consolidated Stock				17	5	4
53	10	0	,, Refreshments	52	1	0				17	5	4							
							171	16	6				,, Interest on 4% Consolidated Stock				20	0	0
			,, *Country Meetings:*—							10	0	0							
			Expenditure	196	13	10				12	8	10	,, Interest on $3\frac{1}{2}\%$ Defence Bonds				17	10	0
12	8	2	*Less* Subscriptions	141	8	0							,, Interest on Post Office Savings Bank Account				22	12	10
							55	5	10	34	5	0							
8	8	0	,, Audit and Accountancy				8	8	0										
4	4	6	,, Insurance				3	19	6										
4	17	6	,, Library and Journals				5	15	9										
26	5	0	,, Northcroft Memorial Lecture				26	5	0										
42	0	0	,, Honoraria				23	2	0										
11	15	9	,, Sundry Expenses				7	5	5										
			,, Depreciation on Furniture and																
34	4	0	Equipment				34	4	0										
			,, *Excess of Income over Expenditure*																
328	5	11	*for the year*				606	19	5										
£1,312	3	3					£1,485	8	3	£1,312	3	3					£1,485	8	3

The British Society for the Study of Orthodontics

BALANCE SHEET as at 30th September, 1956

1955								
£	s.	d.		£	s.	d.	£	s. d.
			Accumulated Fund:—					
			Balance at 1st October, 1955 ..	2,773	19	6		
			Add Excess of Income over Expenditure for the year	606	19	5		
2,773	19	6					3,380	18 11
			Creditors:—					
			Transactions 1955 and 1956 (estimated by the Honorary Treasurer)	850	0	0		
850	0	0	*Dental Practitioner*	75	0	0		
–	–	–	Northcroft Memorial Lecture ..	26	5	0		
26	5	0	Hire of Hall	13	10	0		
19	13	0	Museum Rent	7	17	6		
7	17	6	Printing and Stationery	4	16	0		
–	–	–	Postage	3	11	6		
–	–	–	Subscriptions in Advance ..	8	19	10		
7	18	0	Country Meeting	39	7	8		
–	–	–					1,029	7 6
£3,685	13	0					£4,410	6 5

S. B. NEWTON, T. L. WINN } *Hon. Auditors*
J. S. BERESFORD, *Hon. Treasurer*

1955								
£	s.	d.		£	s.	d.	£	s. d.
			Furniture and Equipment:—					
			Balance at 1st October, 1955 ..	405	5	0		
405	5	0	*Less* Depreciation at 5% per annum	34	4	0		
							371	1 0
			Investments:—					
			500 National Savings Certificates, Seventh Issue at Cost	375	0	0		
			Add Accrued Interest	112	10	0		
				487	10	0		
475	0	0	£691 5s. 10d. 2½% Consolidated Stock at Cost	575	14	0		
575	14	0	£500 0s. 0d. 4% Consolidated Stock at Cost	485	6	3		
485	6	3	£500 0s. 0d. 2½% Defence Bonds at Cost	500	0	0		
500	0	0	(Approximate Market Value £1,731)				2,048	10 3
			Cash at Bank:—					
322	5	10	Westminster Bank Ltd.	1,121	19	1		
919	8	11	Post Office Savings Bank ..	862	1	9		
							1,984	0 10
			Cash in Hand:—					
2	8	10	Honorary Treasurer	2	6	10		
4	2		Honorary Secretary	4	7	6		
							6	14 4
£3,685	13	0					£4,410	6 5

Certified in accordance with the Books and Vouchers of the Society.
We have verified the Investments and Cash at Bank.

21*st November*, 1956.

FREDK. B. SMART & CO.,
Chartered Accountants,
22, Queen Street, London, E.C.4.

SUBJECT INDEX

AUTHOR INDEX